Bear Creek & Bear Lake Watershed Management Plan

MUSKEGON Conservation District

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DEQ Michigan's Nonpoint Source Program

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Mouth of Bear Creek 2004

"...We abuse land because we see it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect…."

Aldo Leopold

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Chapter 1 Executive Summary

The term watershed refers to the entire physical land area or basin drained by a distinct stream or riverine system, physically separated from other watershed by ridgetop boundaries (Doppelt et al., 1993). The Bear Creek & Bear Lake Watershed is located in west-central Michigan and is approximately 11.5 miles long from its start in Dalton Township down to its mouth at Bear Lake channel at Muskegon Lake. Muskegon Lake then flows into Lake Michigan at Muskegon Lake Channel (Figure 1). Both Bear Lake and Muskegon Lake are drowned river mouths. The Bear Creek & Bear Lake Watershed covers a land area of 19,058 acres or approximately 29 square miles. It is oriented in a northeast to southwesterly direction with the headwaters in the northern portion of the watershed. The watershed lies entirely within Muskegon County and is shared by five local governments: Dalton Township, Laketon Township, Cedar Creek Township, Muskegon Township, and the City of North Muskegon.

There are nine tributaries that flow into Bear Creek, including Little Bear Creek and three tributaries that flow directly into Bear Lake. The Primary tributaries include Little Bear Creek, Ribe Drain, Furman Drain, Brandstrom Drain, and Pillon Staple tributary. There are 16 subbasins (or subwatersheds) that make up the 19,058 acre Bear Creek & Bear Lake Watershed (Figure 2). Bear Creek is fed by ground water, surface runoff, lakes, agricultural drains, and both warm and cold water tributaries.

The geology, and soils of the Bear Creek & Bear Lake Watershed demonstrate the variation of the county's land characteristics (Figure 3). The area has diverse soil composition resulting from the latest glacial period. As the glaciers melted and retreated, a covering of raw soil material was left on the surface of the county. This glacial deposit ranges from about 150 feet to greater than 400 feet thick (USDA 1968). The northeast part of the watershed near Twin Lake is the area with the highest elevation. The majority of the areas with significant elevation changes occur adjacent to Bear Creek and its tributaries where uplands descend to valleys (Figure 5).

Land use/land cover in the Bear Creek & Bear Lake Watershed is dominated by forest. Forests are found throughout the watershed but are most abundant in the middle and upper portions. Agriculture, including both cropland and pasture areas, is most abundant east of the US -31 in the northern portions of the watershed (Figure 9). Urban residential uses are concentrated around Bear Lake, Twin Lake, and along major roadways specifically the M-120 corridor. Rural residential areas are found throughout the rest of the watershed. Due to extensive draining and channeling in the upper parts of the watershed few wetland areas remain. The major wetland areas in the watershed occur at the mouth of Bear Creek into Bear Lake and adjacent to Little Bear Creek below Russell Rd. to its confluence with Bear Creek (Figure 10).

In 1997, a collaborative group was formed to discuss the state of the Muskegon River Watershed, of which the Bear Creek/Bear Lake Watershed is a subwatershed. As a result, in 2000 Grand Valley State University – Annis Water Resources Institute received a Watershed Management Planning Grant for the Muskegon River Watershed from the U.S. Environmental Protection Agency and the Michigan Department of Environmental Quality. Furthermore, Muskegon Lake and the immediate drainage area, including the Bear Creek and Bear Lake Watershed, is one of 43 specific locations in the Great Lakes region that are formally designated as Areas of Concern (AOC). This designation is a part of the Great Lakes Water Quality Agreement between the United States and Canada. There are 14 AOCs that are fully or partially under Michigan jurisdiction, one of which is Muskegon Lake, at the outlet of the Muskegon River. A remedial Action Plan (RAP), prepared for each AOC, highlights the problems and Beneficial Use Impairments (BUI). Two updated RAPs have recommended remedies to be implemented in order to restore Muskegon Lake's ecosystem integrity and to remove it from the AOC list. The Bear Creek and Bear Lake Watershed discharges its water into Muskegon Lake via the Bear Lake Channel and therefore is high priority due to its direct impact on the Muskegon Lake AOC.

In 2002 the Muskegon Conservation District received a Watershed Management Planning Grant for the Bear Creek and Bear Lake Watershed from the U.S. EPA and the Michigan DEQ. The grant, authorized by section 319 of the Federal Clean Water Act, was used to develop this Bear Creek & Bear Lake Watershed Management Plan which began in October of 2002.

The Michigan Water Quality Standard, established in 1968, recently revised in 1994, are a set of rules describing the water quality to be achieved in Michigan's waterbodies. The standards identify the minimal uses for which Michigan waters are to be protected (Sayles, 1996). The Water Quality Standards require water bodies to meet the set standards, unless the degraded condition is due to natural causes. The Bear Creek and Bear Lake Watershed Advisory Committee was formed to identify and address the issues that surround the impaired designated uses in the Watershed, and to inform the community on how to restore, protect, and improve water quality, and to inspire community involvement (Table 1).

Table 1: Designated Uses In The Bear Creek / Bear Lake Watershed

Designated Uses	Nonattainment (Impaired) or Threatened status
Cold-water fishery	Nonattainment/Impaired
Aquatic life and wildlife	Nonattainment/Impaired
Partial body contact recreation	Nonattainment/Impaired
Total body contact recreation	Nonattainment/Impaired
Warm-water fishery	Threatened (*to be protected*)
Navigation	Threatened (*to be protected*)
Agriculture	Attainment
Industrial water supply	Attainment
Public water supply	Attainment

Little Bear Creek upstream of T10N, R16W, Muskegon Charter Township, Section 8, and all upstream areas are State designated coldwater trout streams. Areas above and below this point on Bear Creek are not classified as coldwater streams. However, this does not mean that Bear Creek is not a coldwater stream, it may have missed formal designation due to degraded habitat conditions. Most coldwater streams are designated trout streams, but not all. Designated trout streams receive more restricted water quality protection under state surface water quality rules. Degradation can eliminate and reduce coldwater fish populations in a stream but they still have coldwater stream characteristics and are important to the watershed. It is suspected that the upper reaches of the watershed, particularly in the drained areas, are not capable of supporting coldwater fisheries because of elevated summer temperatures and loss of habitat from excessive sedimentation. These degraded areas not only affected the coldwater fishery designated use but also impact other designated uses listed in Table 1.

Although much emphasis historically has been placed on point sources of pollution, citizens and officials in the Bear Creek & Bear Lake Watershed have become increasingly concerned with nonpoint sources of pollution which can degrade water quality and aesthetic enjoyment. Section 319 of the Clean Water Act (1987) is one of the most important tools for controlling nonpoint source pollution. Nonpoint sources are those pollution sources where sediments, nutrients, fertilizers, pesticides, etc. enter a waterbody through surface water runoff or groundwater inputs. These pollutants often degrade water quality, destroy aquatic habitat diversity, and are aesthetically displeasing.

Sedimentation, excessive nutrient loadings, microorganisms, toxic substances, thermal pollution, and invasive species are pollutants that are threatening the state designated uses for the Bear Creek and Bear Lake Watershed.

> ***Erosion and Sedimentation*** refer to two separate phases of detaching material in one place, transporting it, and depositing it in another. Erosion refers to the detachment and transport of the material and sedimentation to its deposition (Satterlund & Adams, 1992). There are several identified nonpoint sources of

sediment in the Bear Creek and Bear lake Watershed including: streambank erosion sites, road / stream crossings, natural erosive causes, and erosion occurring at construction sites adjacent to water bodies.

Excessive ***nutrient loading*** is another known threat to designated uses in the Bear Creek/Bear Lake Watershed. There is evidence to suggest there are many potential sources in the system where excessive nutrient loadings have been identified and pose a threat to water quality and habitat suitability for diverse aquatic life. These sources include residential fertilizer use, agricultural runoff (from farming and pasture fields), poorly maintained and/or failing septic systems, high erosion, stormwater runoff from urban and residential areas, and runoff from animal waste (from both agriculture and residential sources). Human and animal waste runoff is also a contributing factor to the presence of ***microorganisms*** such as *E.coli* and *Fecal coliform.* These bacteria can act as an indicator of more serious outbreaks, which potentially would lead to restricted use of the waterways.

Toxic Substances, such as oils, grease, and other chemicals are known to be threatening the water quality of the watershed. There is a statewide mercury-based fish consumption advisory that is applied to all of Michigan's inland lakes including Bear Lake. Stormwater and urban runoff from the more urbanized lower end of the watershed and the M-120 development corridor is an ever increasing concern in the Bear Creek & Bear Lake Watershed. Impervious surfaces in these urbanized areas of the watershed contribute to toxic substances during storm events when water runs off streets, parking lots, and roofs and enters storm drains leading to Bear Creek, Lake, and any of their tributaries while getting warmed in the process.

Thermal pollution is the warming of the water temperature to a degree that limits the amount of dissolved oxygen available for use by aquatic life. The primary impact on stream temperatures results from the removal or reduction of streamside or shoreline vegetation that exposes the water surface to direct solar radiation by day and the open sky at night (Satterlund & Adams, 1992). The majority of the agricultural drains in the upper watershed are frequently maintained to deter vegetation from establishing and therefore act as vectors of thermal pollution to the mostly groundwater fed stream system. In addition, stormwater outfalls in the more developed lower end of the watershed and along the M-120 corridor, contribute to the problem of thermal pollution. When rain falls onto hot rooftops, parking lots, or streets it quickly warms as it is directed toward storm-sewers, which directly output into Bear Creek or its tributaries. The result is an increase in water temperature and decreased habitat suitability for the coldwater fishery. These impervious surfaces combined with lack of riparian vegetation in the upper reaches in the watershed are a contributing source of Thermal Pollution.

Non-native ***invasive species*** such as purple loosestrife, Eurasian water milfoil, reed canary grass, honey suckle, phragmities, and many others are a major threat to the Bear Creek and Bear Lake Watershed. Both terrestrial and aquatic systems are considered to be threatened by the continuous influx of biological "invaders". Non-native invasive species compete with native species, alter habitat conditions, and have also shown to have negative economic impacts by degrading both warmwater and coldwater fisheries, and recreational and navigational designated uses.

This Bear Creek and Bear Lake Watershed Management Plan has been developed as a comprehensive nonpoint source management plan which will identify, document, quantify, and prioritize these and other nonpoint sources of pollution in the Watershed listed above. The overall goal of the project is to improve water quality and to restore, improve and protect the designated uses through the development of an information and education strategy, identifying and inventorying critical areas, and by designing and installing Best Management Practices (BMPs) for these areas. This watershed management plan is designed to assist residents, Bear Lake/ Bear Creek Watershed Advisory Committee, landowners, local decision makers, and the entire watershed community in improving the quality of their watershed and to inspire community awareness and involvement.

An Information and Education (I&E) Strategy was developed to effectively improve watershed education, awareness and stewardship for the entire watershed. The I&E Strategy lists the key audiences in the watershed and most effective ways to target these audiences. This Strategy lays the framework for collaboration between community residents, students and teachers, and local decision makers and natural resource managers and lists activities to be implemented. The total cost for the implementation of the Information and Education Strategy for the Bear Creek and Bear Lake Watershed is $48,950 (Appendix A).

Pollution concerns will be addressed using Resource Management System (RMS) Plans. A Resource Management System contains a series of Best Management Practices (BMPs) that meets established water quality levels of treatment for the conservation, wise use, protection or improvement of soil, water, air, plants, and animals (MDNR-SWQD, 1991). It should be noted that many BMPs need to be implemented throughout the Bear Creek and Bear Lake Watershed; however continual inventorying and selection of sites of where to install BMPs needs to occur so that BMPs are tailored to the specific need of individual sites. Anticipated BMPs include, but are not limited, to the following: fertilizer/pesticide management, streambank stabilization, grade stabilization structures, vegetated filter strips, riparian buffer strips, sediment basins, and watercourse crossings. Total costs for the implementation of BMPs is $978,679.28 (Chapter 8.7). Total costs for implementing both the BMPs and the I&E Strategy is $1,027,629.28 (Chapter 8.7).

Future efforts for the Bear Creek and Bear Lake Watershed Project include:

- Information and education activities
- Installation of BMPs in selected sites
- Continual inventorying and selection of BMP implementation sites
- Continual volunteer water quality monitoring to assess environmental conditions
- Continued support of the Bear Creek and Bear Lake Watershed Advisory Committee

Part I: Planning Components

Chapter 2 Description Of The Bear Creek & Bear Lake Watershed

2.1 Location and Size

The Bear Creek & Bear Lake Watershed is located in west-central Michigan and is approximately 11.5 miles long from its start in Dalton Township down to its mouth at Bear Lake channel at Muskegon Lake. Muskegon Lake then flows into Lake Michigan at Muskegon Lake Channel (Figure 1). The Bear Creek & Bear Lake Watershed covers a land area of approximately 29 square miles or 19,058 acres, is oriented in a northeast to southwesterly direction, and lies entirely within Muskegon County. Five local governments share land within the watershed, they include: Dalton Township, Laketon Township, Cedar Creek Township, Muskegon Township, and the City of North Muskegon. There are 16 subbasins within the watershed ranging from 0.28 square miles to 3.78 square miles in size (Figure 2).

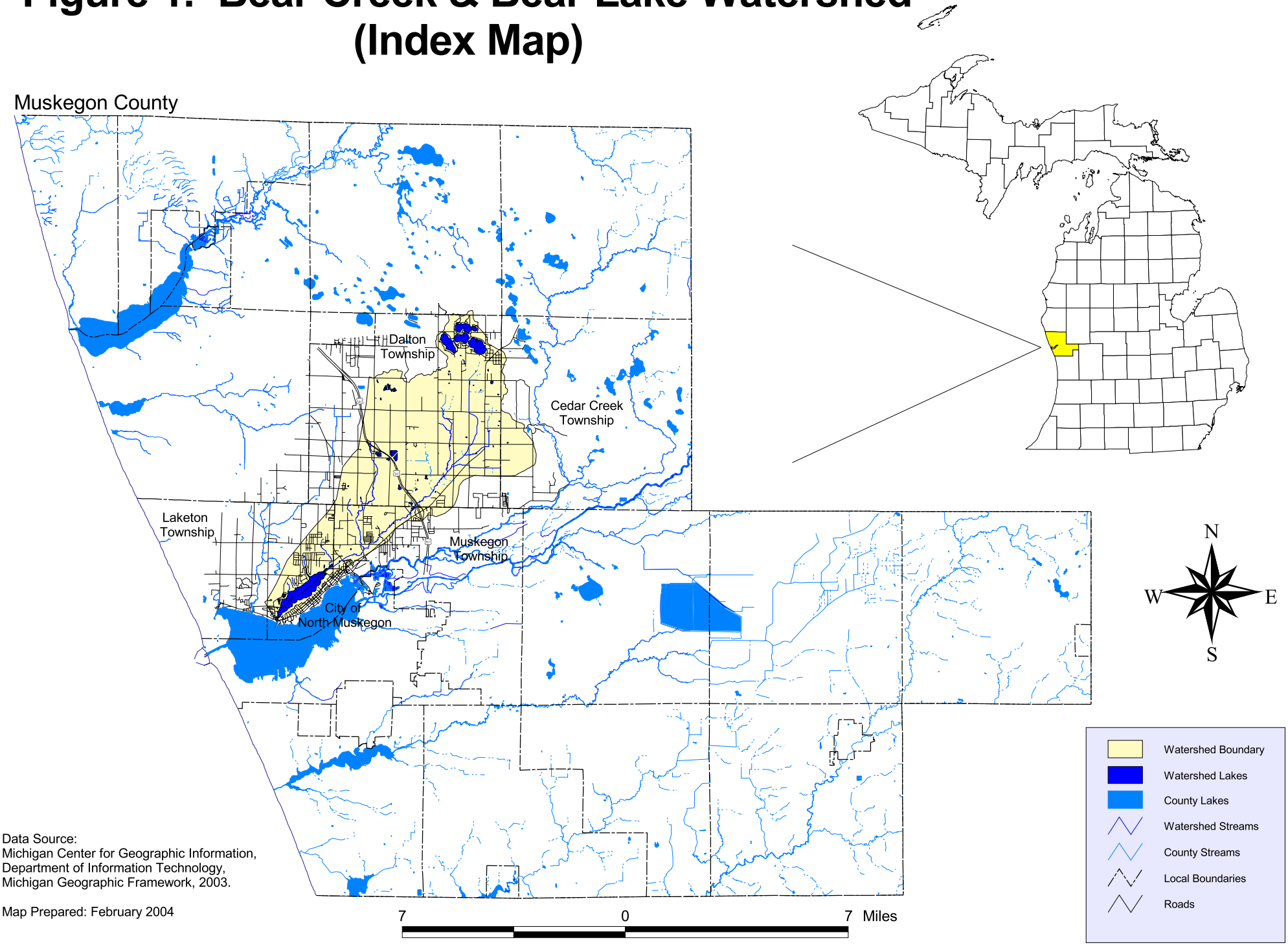
2.2 Geology, Soils, and Topography

The physiography of Muskegon County results mostly from the latest glacial period. As the glaciers melted and retreated from the region they deposited a thick layer of raw soil material, covering the bedrock beneath Muskegon County in their path. This glacial deposit ranges from about 150 feet to greater than 400 feet thick (USDA 1968). The present condition of the county is characterized by nearly level to rolling and hilly land with a belt of strongly rolling sand dunes along the Lake Michigan shoreline.

The geology, soils, and topography of the Bear Creek & Bear Lake Watershed demonstrate the variation of the county's land characteristics. Sandy soils, with generally high permeability and well-drained characteristics dominate the watershed (Figure 3). The central to upper portion of the watershed are characterized by a high water table with hydric soils. Hydric soils are those soils that are currently or were historically saturated with water throughout most of the year and poorly drained with persistent surface water during the growing season. Hydric soils are typically not suitable for intensive development unless they are in a drained state (much of the upper watershed is drained with agricultural ditches, excavations, and road ditches etc.). The soil composition of the watershed can be characterized by three main soil associations.

A. The *Au Gres-Roscommon-Granby association* consists of nearly level and slightly depressional, poorly drained, sandy soils on outwash plains, uplands, and lake plains. This association is found partly in the lower portion of the watershed but primarily in the upper part.

Figure 1. Bear Creek & Bear Lake Watershed (Index Map)



Data Source:
Michigan Center for Geographic Information,
Department of Information Technology,
Michigan Geographic Framework, 2003.

Map Prepared: February 2004

Figure 2. Bear Creek & Bear Lake Watershed

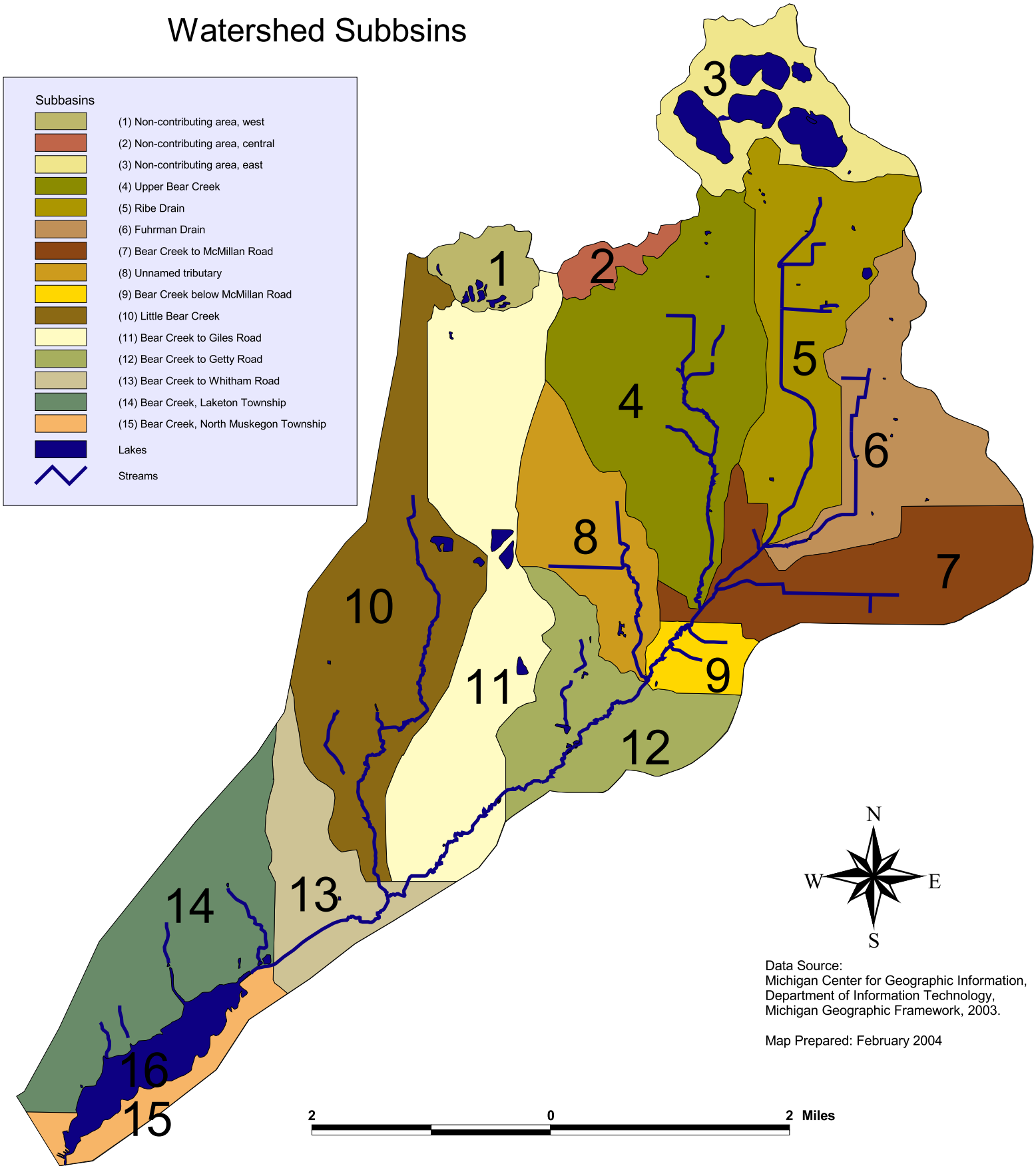
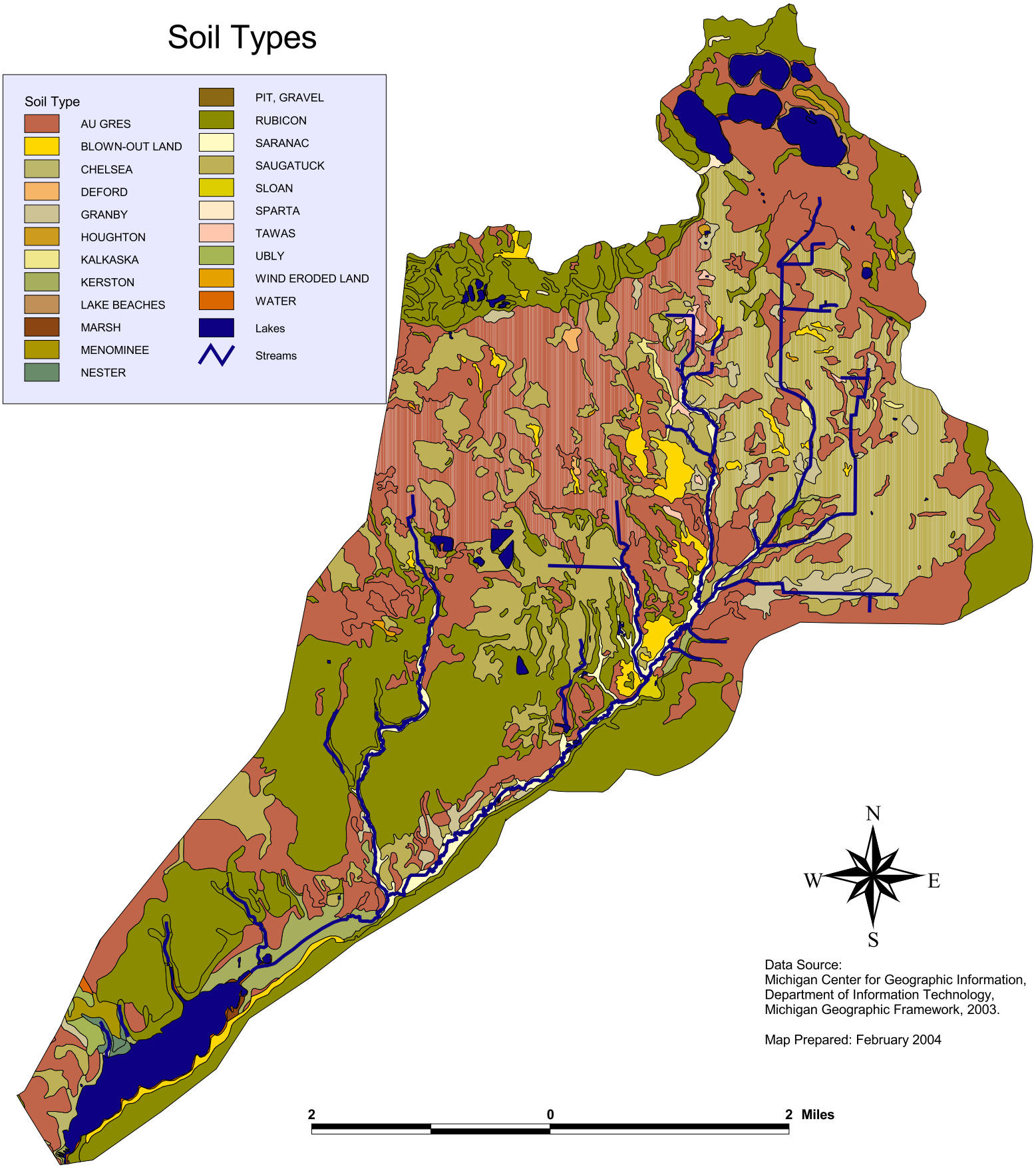


Figure 3. Bear Creek & Bear Lake Watershed



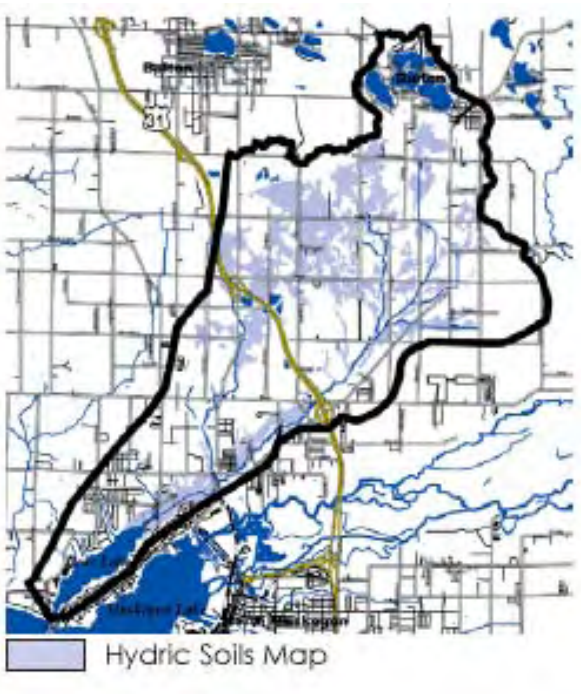
B. The *Rubicon-Croswell-Deer-Park association* is characterized by nearly level to steep, well drained, and moderately well drained sandy soils on outwash plains, beach ridges and dunes. These soils are found in the central part of the watershed, southwest of the highway, and in the northeast portion of the watershed.

C. The *Carlisle-Tawas association* consists of nearly level and depressional, poorly drained peats and mucks. This soil association is found in a small area in the southwestern part of the watershed.

Soils Assessment

The watershed is generally characterized by predominantly sandy composition soils and moderate to high groundwater tables. Approximately 18% of the watershed area has hydric soils (Figure 4). Sandy soils are conductive to infiltration of stormwater and the sandy soils in the Bear Creek and Bear lake Watershed generally have permeability rates of 10 inches/hour. However, the capacity of sandy soils to absorb and treat pollutants such as metals, nutrients, some organic compounds, and bacteria is relatively limited. Thus, areas of sandy soils are more vulnerable to groundwater contamination than soils with greater clay and/or organic content. This is particularly true where the water table is shallow, such as the hydric soils areas (CDF, 2004). In addition, because of the high permeability of the soils in the watershed, surface runoff is rare in the undeveloped areas. Therefore to maintain groundwater recharge, stream baseflows, and moderated high flows, it will be essential to maintain the groundwater based hydrology of the watershed (CDF, 2004). For more information regarding effective management of stormwater in the Bear Creek and Bear Lake Watershed refer to the Stormwater Management Plan, Appendix C.

Figure 4. Hydric Soils of the Bear Creek and Bear Lake Watershed, - Source Conservation Design Forum, 2004.



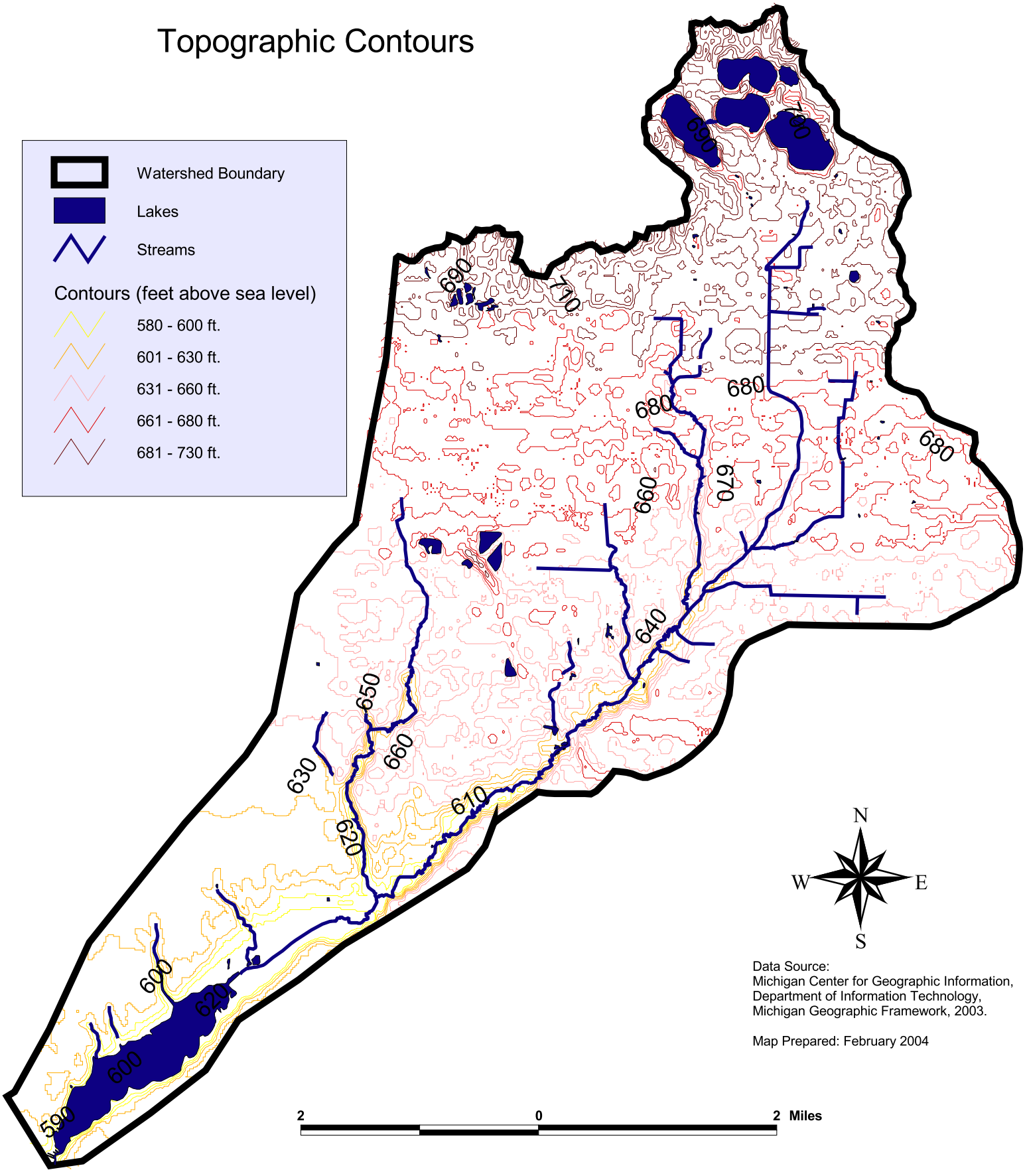
The watershed is nearly level to rolling in topography. The northeast part of the watershed near Twin Lake is the area with the highest elevation. The land adjacent to Bear Creek and its tributaries is the only area where significant elevation changes occur in the form of uplands descending to river valleys (Figure 5).

2.3 Water Bodies

There are nine tributaries that flow into Bear Creek, including Little Bear Creek and three tributaries that flow directly into Bear Lake. The primary tributaries include Little Bear Creek, Ribe Drain, Furman Drain, Brandstrom Drain, Pillon-Staple, and Putman-Bard. There are 16 subbasins that make up the 19,058 acre Bear Creek & Bear Lake Watershed (Figure 2).

Upper Portion of the Bear Creek & Bear Lake Watershed
The upper portion of the watershed encompasses the watershed from its headwaters down to the crossing of U.S. Highway 31. It contains portions of Dalton Township, Cedar Creek Township, and Muskegon Township and lies completely within Muskegon County. Major tributaries in the upper portion of the watershed include: Branstrom Drain, Furman Drain, Ribe Drain, Pillon Staple, and Putnam-Bard (Figure 6). Lakes in the upper part include: North Lake, West Lake, Twin Lake, and Middle Lake. The area is scattered with numerous other small lakes and ponds. Streams in the upper watershed are typically groundwater fed with many drainage ditches contributing to their flow. It is

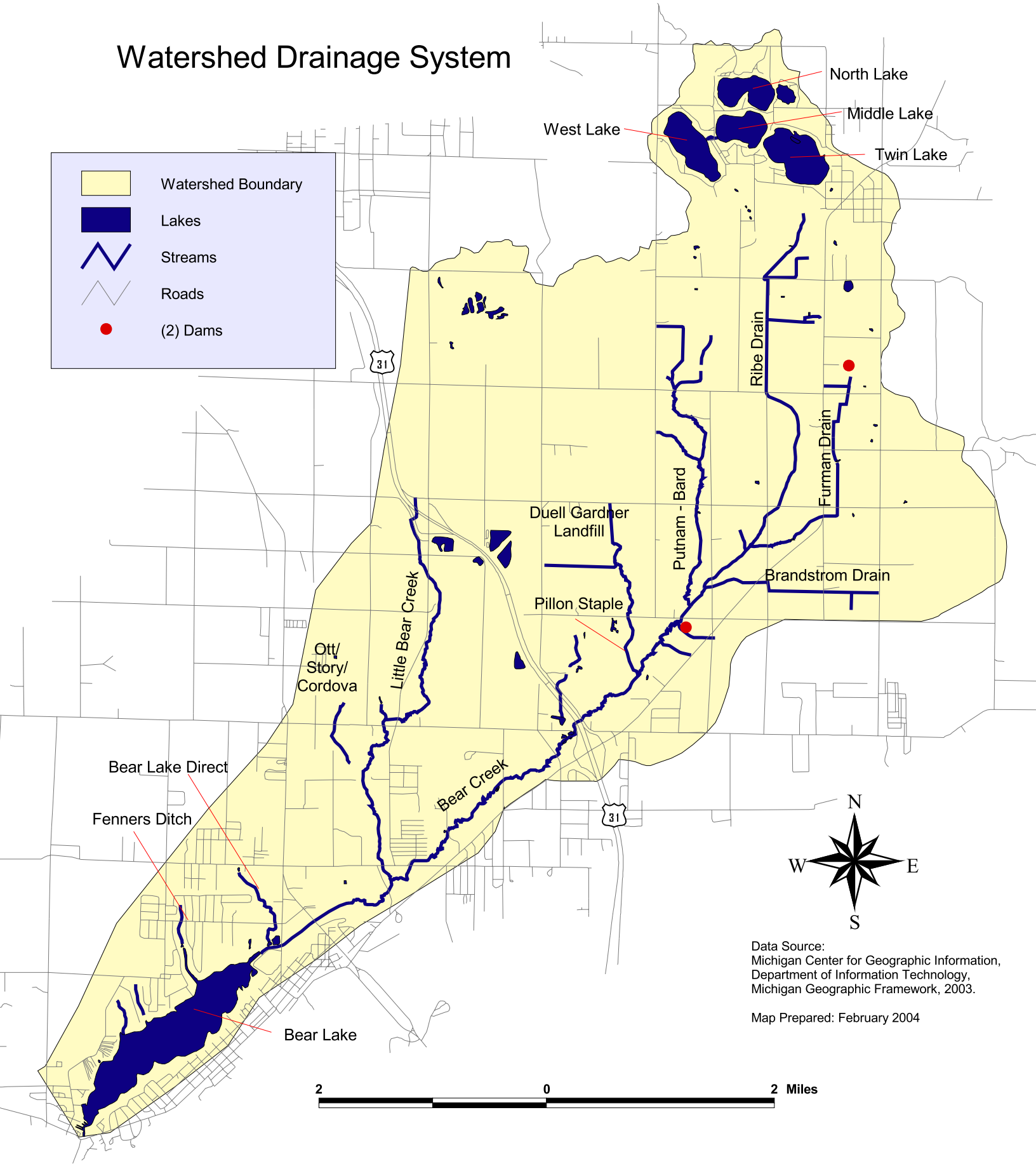
Figure 5. Bear Creek & Bear Lake Watershed



Data Source:
Michigan Center for Geographic Information,
Department of Information Technology,
Michigan Geographic Framework, 2003.

Map Prepared: February 2004

Figure 6. Bear Creek & Bear Lake Watershed



Data Source:
Michigan Center for Geographic Information, Department of Information Technology, Michigan Geographic Framework, 2003.

Map Prepared: February 2004

important to recognize that because of the extent of drainage ditches in the upper portion of the watershed the natural ground water level has been lowered.

There are two dams in this part of the watershed, both are on drains. One on the upper part of Furman Drain and the other on an unnamed drain upstream of U.S. Highway 31 (Figure 6).

Water chemistry / quality
The use of fertilizers and the presence of septic systems may be increasing the amount of phosphorous and nitrogen in the soil and ground water. Due to the hydric nature of the upper portion of the watershed the area is characterized by many historical agricultural drainage ditches and road side ditches. These ditches increase the potential for both nutrient loading and bacterial contamination of Bear Creek and Bear Lake from surrounding residential, agricultural, and livestock land uses. The majority of the agricultural and roadside ditches flow into Bear Creek and then eventually to Bear Lake. In addition to sources in the lower portion of the watershed, these sources contribute to the nutrient loading and algal blooms occurring in Bear Lake. Consistent monitoring of nutrient inputs and concentrations in the upper portion of the watershed is needed, and may provide valuable information regarding excessive nutrient loading of Bear Lake.

Lower Portion of the Bear Creek & Bear Lake Watershed
The lower portion of the watershed encompasses the land area from the crossing of U.S.-31 to the outlet of Bear Lake at Bear Lake Channel into Muskegon Lake. It lies completely within Muskegon County and contains portions of Dalton Township, Muskegon Township, Laketon Township, and the City of North Muskegon. The main tributary in the lower portion is Little Bear Creek. In addition, there are three tributaries that empty directly into Bear Lake: Fenner's Ditch, Bear Lake Direct 1 and Bear Lake Direct 2. The slopes in this portion of the watershed are nearly level to slightly rolling in grade with the greatest elevation changes occurring adjacent to Bear Creek, Bear Lake and their tributaries.

Bear Lake is a 415-acre lake with an average depth of 7 feet (Figure 6). Michigan Department of Environmental Quality has most recently done surveys/sampling of Bear Lake in 2002. It has been determined that Bear Lake is impaired for fish consumption advisories (FCAs) for polychlorinated biphenyls (PCBs) and Mercury. In addition, it is impaired for nutrient enrichment, and nuisance algal growth (MDEQ 2002). Bear Lake is a eutrophic system with high nutrient concentrations. It is suspected that the majority of the excess nutrients are resulting from a combination of lack of riparian vegetation, failing or poorly maintained septic systems, and over fertilization of residential lawns.

Both surface runoff and ground water feed the streams in the lower portion of the watershed. Sandy soils dominate the watershed allowing stormwater to infiltrate through soils to the groundwater and eventually to the stream. Groundwater-fed streams are typically hydrologically stable in both flow rates and temperature. These unique characteristics keep the water cold and the flow stable, which are two key elements in supporting coldwater fisheries. Little Bear Creek upstream of T10N, R16W, Muskegon

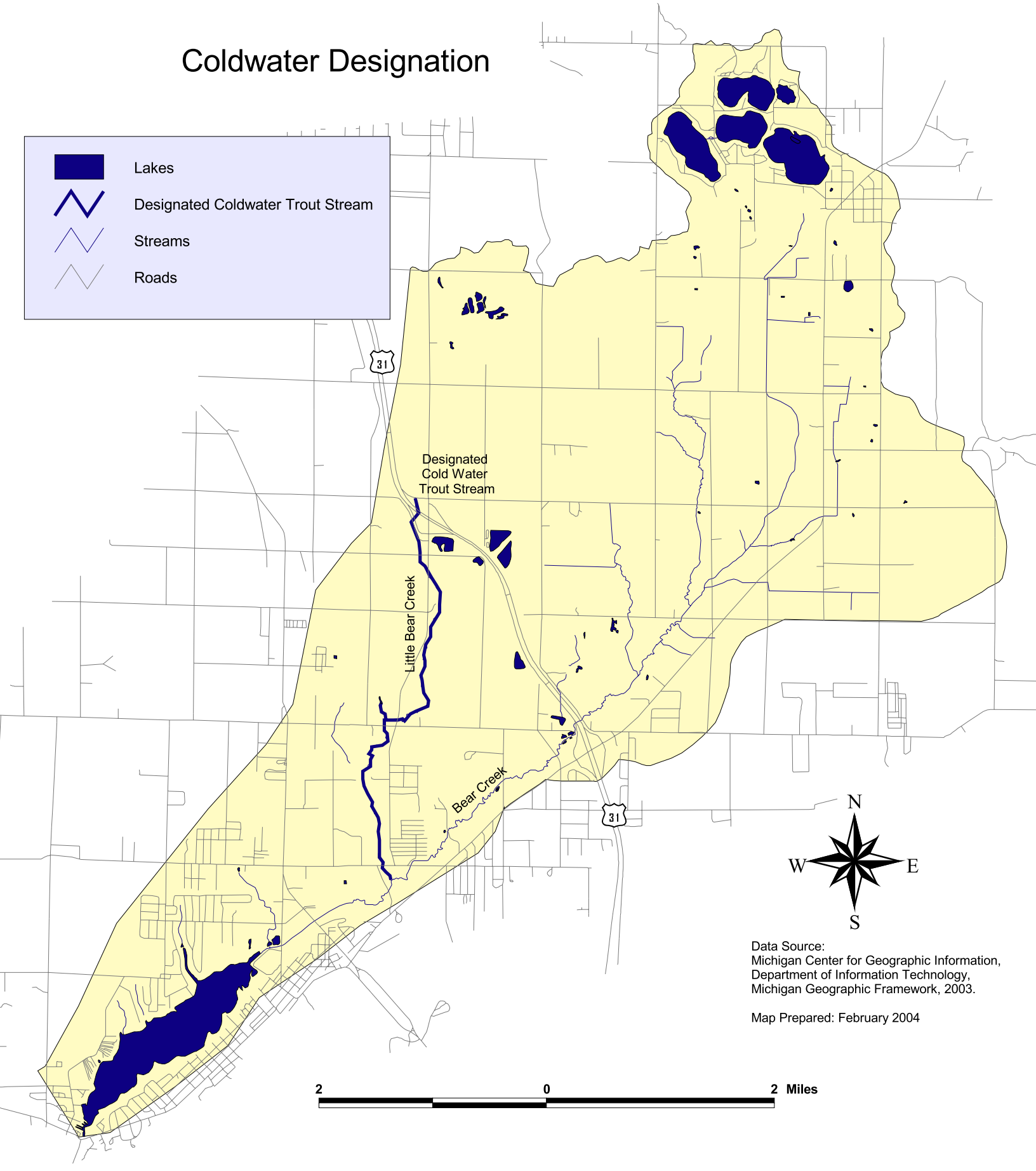
Township, Section 8, and all upstream areas are designated as coldwater trout streams (Figure 7). All areas above and below this point on Bear Creek are not classified as coldwater streams. However, this does not mean Bear Creek is not a coldwater stream. Bear Creek may have been overlooked for coldwater designation because of conditions caused by development or dams on the system made it unsuitable for coldwater fish. Both Little Bear Creek and Bear Creek are classified under the Valley Segment Ecological Classification system, meaning they have similar hydrologies. For example, July water yield for Bear Creek at Getty Street at 0.4 cfs/ square mile. Summer yields for Lower Michigan coldwater streams ranges from 0.33 - 1.2 cfs/square mile. This suggests that Bear Creek falls within the lower range for coldwater streams (MDNR, 2002). In addition trout have been collected in Bear Creek indicating that Bear Creek should be classified as a coldwater stream. Most coldwater streams are designated trout streams, but not all. Designated trout streams receive more restricted water quality protection under state surface water quality rules. Degradation can eliminate and reduce coldwater fish populations in a stream but they still have coldwater stream characteristics and are important to the watershed. Undisturbed flow of the stream is crucial for fish and other aquatic organism survival. Dams, ponds, or other water level control structures alter flow characteristics and degrade habitat suitability by slowing water flow and increasing water temperature. In the lower portion of the Bear Creek and Bear Lake Watershed there are no dams.

Water chemistry / quality

The Michigan Department of Environmental Quality (MDEQ) conducted a survey in June of 2001. The survey shows a marked improvement over 1985 stream conditions. Sampling was done on a limited basis but acceptable macroinvertebrate populations were observed at all locations surveyed. In addition, much more taxonomic diversity was found in 2001 than in 1985. Little Bear Creek, upstream of River Road, in a former venting area for the Ott / Story/ Cordova company, stoneflies are now present and many more taxa are also now present that were not observed in the 1985 MDEQ survey. In addition, no chemical odors and no slime growths were noted, not even in the Unnamed tributary upstream of River Road. Overall the study suggests that water quality is improving and is now acceptable. Water quality improvements are likely a result of groundwater capture and treatment starting in the mid-1990's at the Ott / Story / Cordova EPA Superfund site. The 2001 study shows that fish numbers are increasing at River Road but it is recommended that additional fish community sampling be conducted to assess the overall integrity of the stream and its habitat.

Stormwater and urban runoff, containing oils, grease, dissolved nutrients, solids, and other pollutants is an ever increasing concern in the Bear Creek & Bear Lake Watershed. Impervious surfaces in urbanized areas of the watershed contribute to toxic substances during storm events when water runs off streets, parking lots, and roofs and enters storm drains leading to Bear Creek, Bear Lake, and any of their tributaries. In addition, stormwater outfalls contribute to the problem of thermal pollution. When rain falls onto hot rooftops, parking lots, or streets it quickly warms as it is directed toward storm sewers which directly output into local surface water. The result is an increase in water temperature and decreased in-stream habitat suitable for the coldwater fishery.

Figure 7. Bear Creek & Bear Lake Watershed



Ott / Story / Cordova
The Ott / Story / Cordova NPL (National Priority List) site located in Section 32 in Dalton Township is a former organic chemical production facility that operated from 1957 until 1985 (Figure 6). The facility used as many as five unlined seepage lagoons to dispose of industrial wastewaters and production vessel residues. These practices resulted in contamination of groundwater, soils, and nearby Little Bear Creek and its unnamed tributary. Approximately 10,000 drums of waste material, some of which contained phosgene gas, were also stockpiled on-site. The former production area is approximately 20 acres in size, surrounded by wooded undeveloped land and a semi-rural residential area with approximately 300 to 500 residents in a one-mile radius of the site (USEPA 2002). For a more detailed description of point sources of pollution, refer to Chapter 3.3.

Duell & Gardner Landfill
The 40-acre Duell & Gardner Landfill site, located in Dalton Township was an operating municipal landfill from the 1940's to 1975 (Figure 6). Before 1969, industrial waste and general refuse were accepted at the site. From 1969 to 1973, the landfill was operated as a licensed solid waste disposal facility. In 1971, the Michigan Department of Public Health (MDPH) stipulated that no liquid waste was to be disposed of in the landfill; however, in 1973, the MDPH noted that liquid waste disposal was occurring. The landfill ceased operations in 1975 (USEPA 2002). Wastes were deposited on the soil surface and in surface depressions. For a more detailed description of point sources of pollution, refer to Chapter 3.3.

2.4 Climate

The Bear Creek & Bear Lake Watershed is located at latitudes where polar and tropical air masses meet to create rapidly changing weather patterns. As a result of the close proximity to Lake Michigan and the primarily westerly winds, the Bear Creek & Bear Lake Watershed experiences a 'lake effect' climate. Because of the prevailing westerlies, the influence of Lake Michigan is strong. Overall the weather remains milder with cooler summers and warmer winters in the watershed. The lake effect is minimal as you move further inland where it is limited to increased cloudiness during late fall and early winter. Lake Michigan traditionally creates heavy 'lake effect' snow amounts for bordering areas including all of Muskegon County and the Bear Creek & Bear Lake watershed (Michigan Department of Agriculture- MDA).

In spring the waters from Lake Michigan cool the warm air that reaches the area thereby delaying the growth of plants until frost is no longer likely. Conversely in the fall, Lake Michigan's waters, still warm from summer, warm the cool air moving into the area which will delay the first frost. This process gives more time for plants to mature in the fall, and also contributes to the formation of heavy snowstorms and squalls over Lake Michigan. Average annual snowfall in Muskegon County is 74 inches, as compared to approximately 40 inches in central and east-central Michigan (USDA, 1968).

The average annual temperature ranges from a low of 39.5 degrees Fahrenheit to a maximum of 56.9 degrees Fahrenheit. The warmest season, summer, averages about 69 degrees F, and the coldest season, winter, averages about 27 degrees F. The average annual precipitation for Muskegon County is 31.22 inches (USDA, 1968).

2.5 Population

Within the Bear Creek & Bear Lake Watershed there are five local governments. They are: City of North Muskegon, Dalton Township, Muskegon Township, Laketon Township, and Cedar Creek Township. 2000 Census data reveal that there are approximately 16,152 people that live within the watershed. The southwestern, lower portion is the most heavily populated part of the watershed. This population is mainly centered in the area that surrounds Bear Lake in the city of North Muskegon and in Laketon Township. The corridor running along M-120 from North Muskegon to Twin Lake is another densely populated area in the watershed that is experiencing ongoing population growth and expansion.

Because township borders and census tracts do not follow the watershed boundary it is near impossible to get a precise estimate on the exact population within the Bear Creek & Bear Lake Watershed. However in the initial stages of the watershed planning process an accurate estimate was made using 2000 census data which put the number of residents living within the watershed at 16,152.

A regional look at the area shows that the city of Muskegon is experiencing a decline in population within city boundaries while substantial growth in neighboring cities and townships is occurring. Partly because of this, the Bear Creek & Bear Lake Watershed is experiencing significant growth. Census data show a 5.6% increase in the number of residents within the watershed between 1990 and 1995.

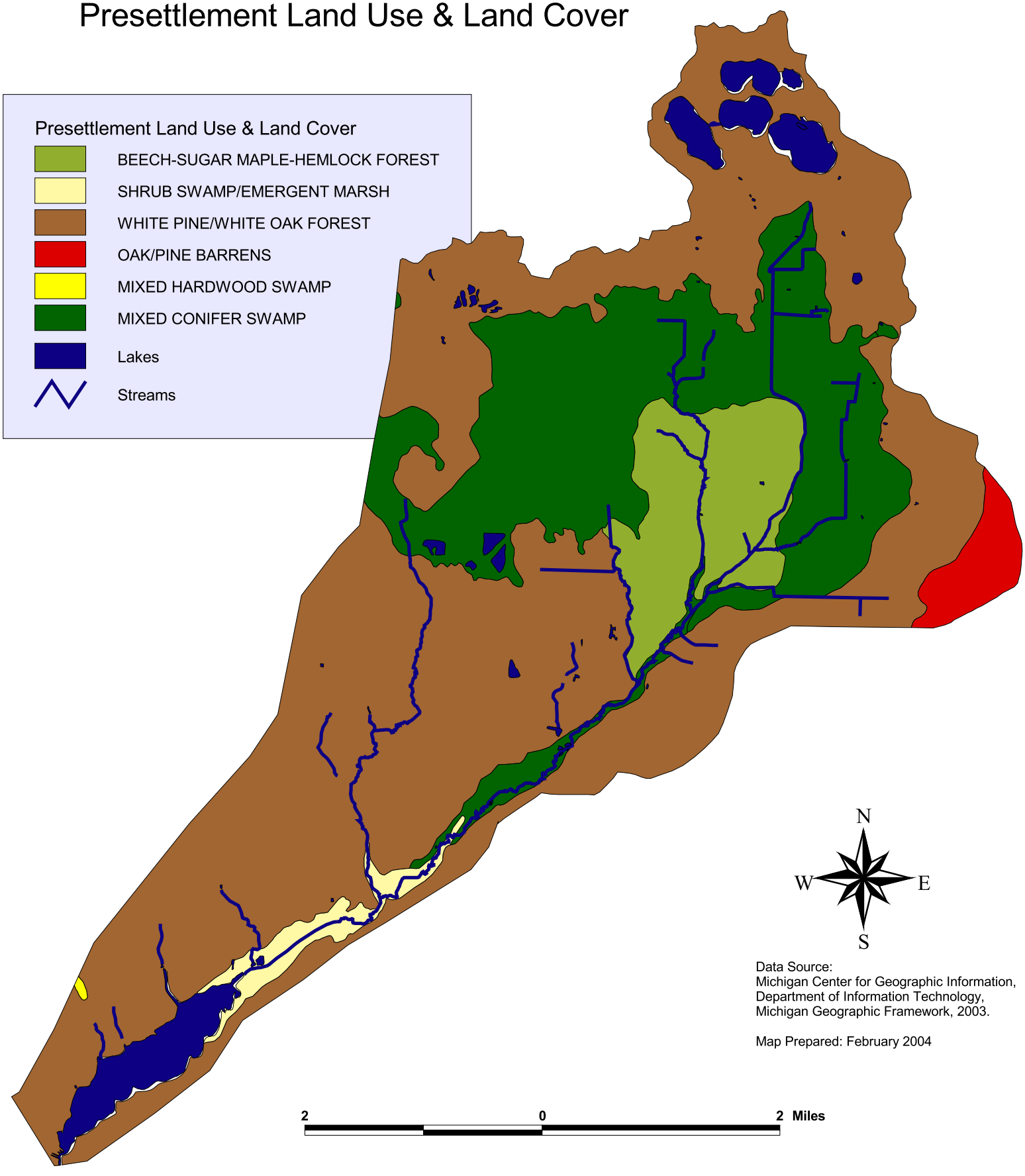
The growing population's expansion and development is increasing the pressure on the ground water supply, remaining open spaces, wetlands, and other waterways. Along with the population comes a need for water, water treatment, wastewater management, storm water management, roads, impervious surfaces, and agricultural, commercial, and industrial land uses. All of these changes within the Bear Creek & Bear Lake watershed will have marked effects on water quality.

2.6 Land Use

Prior to the settlement by Europeans in the 1800's the dominant native vegetation was white pine and mixed hardwood forests, beech, sugar maple, and hemlock forests, and mixed conifer swamps (Figure 8). Logging, agriculture, and degradation and fragmentation resulting from development, have drastically changed the presettlement landscape. Currently forests cover a large portion of the watershed but much of the original forests have been converted to residential and industrial uses (Table 2).

Figure 8. Bear Creek & Bear Lake Watershed

Presettlement Land Use & Land Cover



Data Source:
Michigan Center for Geographic Information,
Department of Information Technology,
Michigan Geographic Framework, 2003.

Map Prepared: February 2004

Table 2. Current Land Uses in the Bear Creek & Bear Lake Watershed

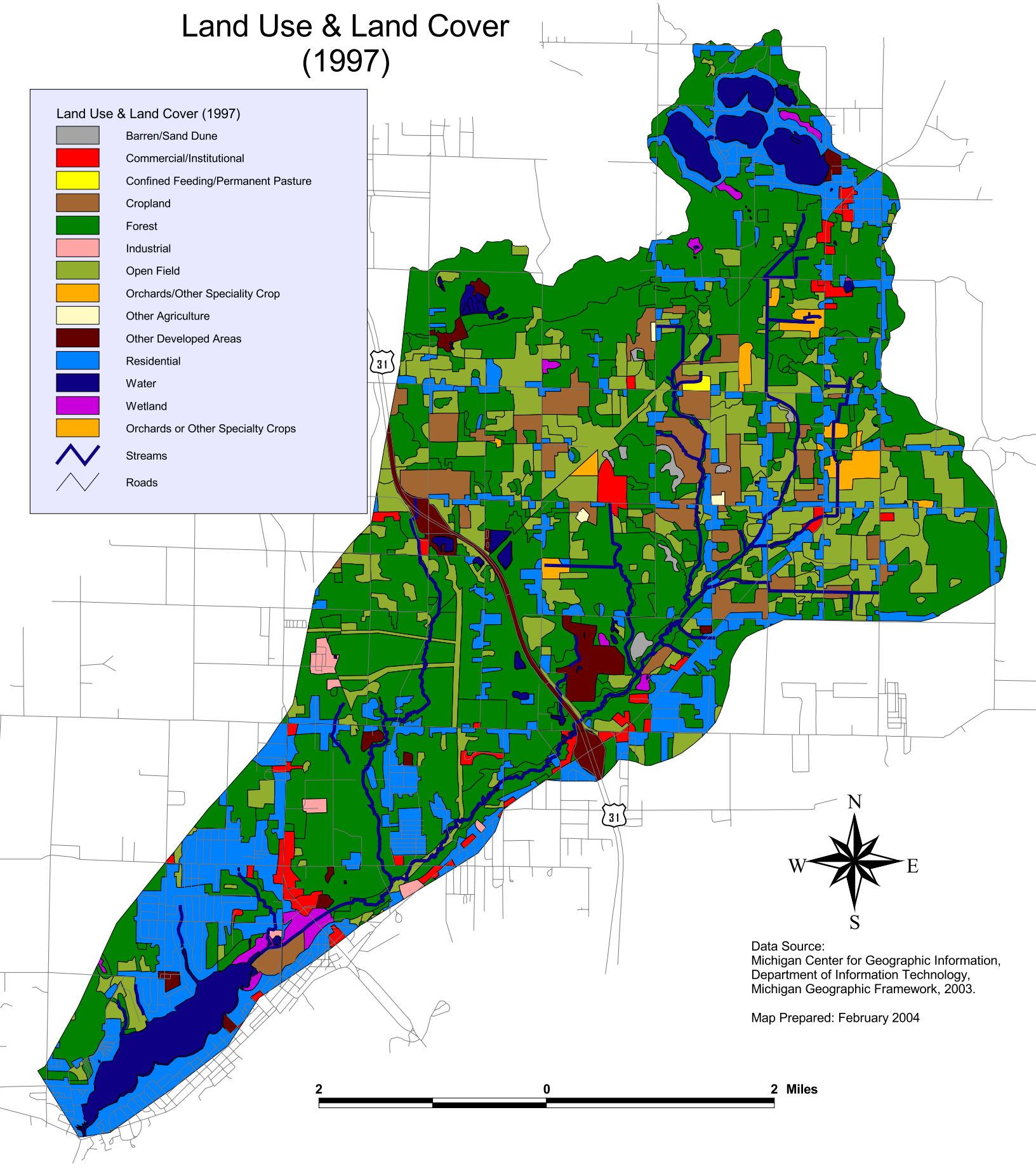
Land Use	Acres	Percent
Forest	10190.4	44
Urban	5095.2	22
Agriculture	1389.6	6
Wetland	231.6	1
Other	6253.2	27
Total	**19,058**	**100**

Forests dominate the middle and upper portions of the watershed. Agriculture is minimal to the west of the highway, with the majority east of the highway in the northern portions of the watershed (Figure 9). The residential uses are concentrated around Bear Lake and along major roadways specifically the M-120 corridor. Due to extensive draining and channeling in the upper parts of the watershed, few intact wetland areas remain. The major wetland areas in the watershed occur at the mouth of Bear Creek into Bear Lake and adjacent to Little Bear Creek below Russell Rd. to its confluence with Bear Creek (Figure 10).

Future Land Use

Based on current land use zoning plans for all townships in the Bear Creek and Bear Lake Watershed and the build-out analysis done by MDEQ as part of their Hydrologic Study of the Bear Creek Watershed 2003 (Appendix F), land use proportions are expected to change drastically in the future build-out scenario. The values for each land use were calculated under the assumption that the land areas will be developed to the maximum allowable extent under current zoning recommendations. The build-out analysis demonstrates the need for effective land use planning to ensure that community character is maintained and that water quality in the Bear Creek and Bear Lake Watershed is preserved. Refer to chapter 3.8 for Bear Creek and Bear Lake Watershed Build-Out Analysis**.**

Figure 9. Bear Creek & Bear Lake Watershed



Data Source:
Michigan Center for Geographic Information,
Department of Information Technology,
Michigan Geographic Framework, 2003.

Map Prepared: February 2004

Figure 10. Bear Creek & Bear Lake Watershed

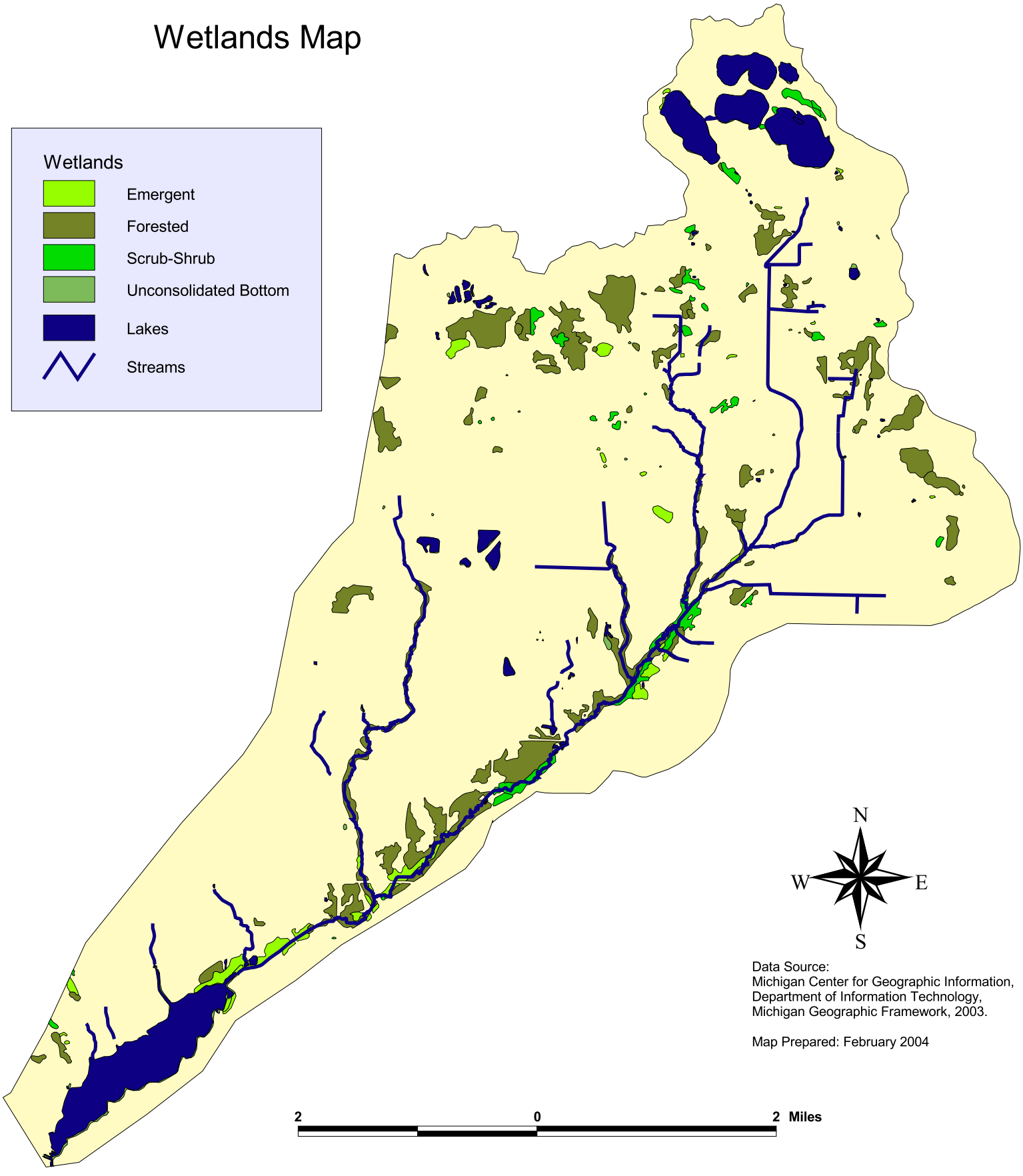
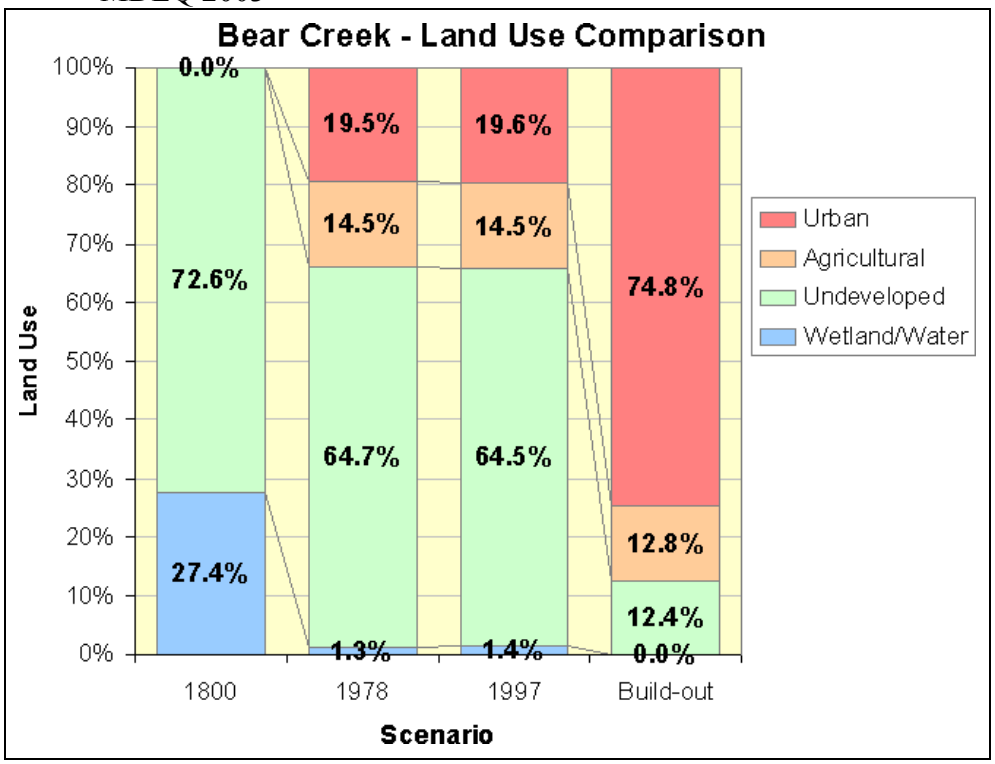


Figure 11. Bear Creek and Bear Lake Watershed Land Use Comparison – Source MDEQ 2003



2.7 Stream Hydrology

The hydrology of a river or stream is a critical factor in the sustenance of its aquatic life. A stream's hydrology is mainly determined by the types of soils present, geology, and land use within the watershed (O'Neal 1997). Unstable water flow, meaning high seasonal and daily fluctuations in discharge, occurs in streams where surface water runoff contributes a high percentage of the water entering the stream. During a period of heavy snow melt or a storm event, water flows quickly into streams increasing the streams velocity, water volume, and its capacity to erode stream banks and aquatic habitats in the substrate. In areas experiencing development, the construction of stormwater management devices may be removing the stability of natural hydrologic processes and thereby contributing to the increase of both the volume and rate of surface water runoff and associated erosion (refer to chapter 3.8 for build-out analysis). In streams where groundwater supplies the main source of water flow, flows are characteristically stable with low seasonal and daily fluctuations in discharge. Because of the lack of erosion and flow fluctuation in these systems, aquatic habitats in the substrate are preserved, and temperatures remain moderate with little variation.

Contributing factors to the destabilization of a streams hydrology include: removal of wetlands and riparian vegetation, drainage ditches, irrigation, water discharges, hydroelectric dams, storm water outfalls, logging, and water-level control structures. With considerable growth occurring in the watershed it has become imperative to develop

innovative and effective storm water management practices that will help restore and sustain the long-term integrity of the Bear Creek & Bear Lake Watershed (see Appendix C, Bear Creek and Bear Lake Watershed Stormwater Management Plan).

Figure 12. Runoff Comparisons in Several Different Land Use Scenarios – Figure from A Hydrologic Study of the Bear Creek Watershed, Appendix F – MDEQ 2003

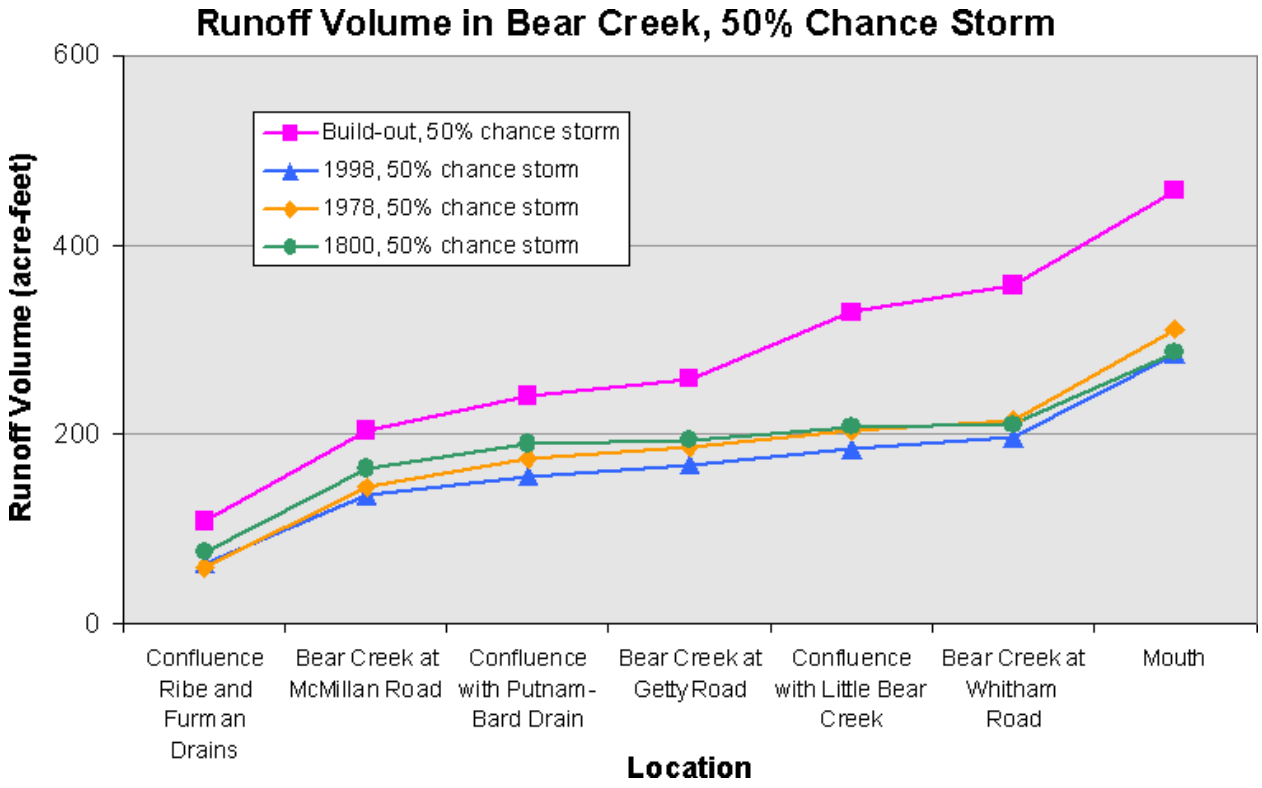
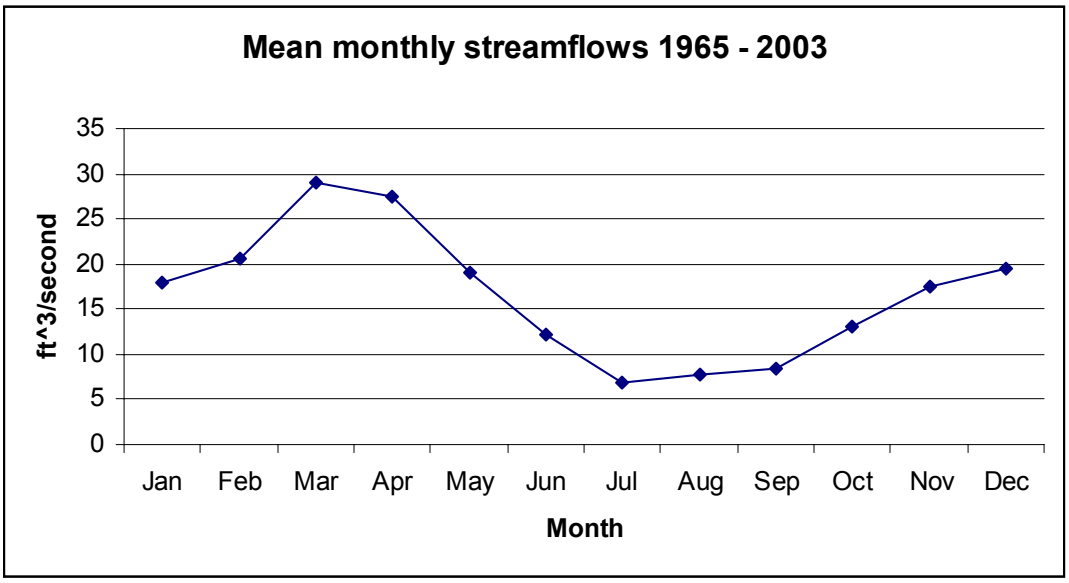


Table 3. Bear Creek Historical Monthly Streamflow Data – USGS Gauging station

YEAR	Monthly mean streamflow, in ft^3/s											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1965										17.0	14.8	33.2
1966	16.2	31.1	31.1	25.9	14.6	6.79	4.94	5.28	4.63	5.90	13.0	25.5
1967	23.0	15.8	25.4	45.6	17.6	14.0	6.09	5.37	4.92	10.1	22.6	18.4
1968	18.2	28.6	18.0	14.5	12.5	10.4	6.62	5.24	5.24	5.92	7.68	11.3
1969	24.6	13.2	15.3	27.4	12.7	16.4	9.17	3.72	3.70	14.1	15.8	10.8
1970	10.7	12.0	28.2	22.4	16.9	9.98	8.70	4.87	10.3	10.3	18.3	17.7
1971	10.3	22.3	36.6	23.8	11.5	7.14	3.17	2.29	3.09	3.48	4.54	12.9
1972	9.80	8.57	16.5	14.7	10.3	5.45	5.99	15.0	9.76	18.1	16.7	20.9
1973	25.7	13.9	26.1	24.2	26.4	12.1	6.91	4.52	4.00	5.38	8.48	13.6
1974	24.9	17.3	35.9	48.1	45.2	22.6	6.10	6.11	4.24	7.92	9.44	11.2
1975	20.1	16.9	28.3	20.6	12.9	17.7	6.09	15.7	22.6	10.7	25.5	34.3
1976	17.3	47.8	87.9	30.7	41.0	15.3	9.58	5.25	4.06	3.89	4.72	4.98
1977	6.15	7.43	31.1	18.3	6.84	4.32	3.61	3.50	5.36	10.3	12.7	23.9
1978	11.8	13.0	29.6	29.0	18.2	11.8	6.53	15.0	16.9	23.6	17.4	15.7
1979	16.2	14.0	59.4	36.9	22.9	8.58	6.10	5.85	3.48	5.33	8.79	17.0
1980	18.6	10.7	12.2	32.7	11.7	12.7	5.62	30.2	15.5	21.4	17.5	20.4
1981	12.8	42.5	20.1	34.7	23.9	13.6	6.67	4.73	7.38	45.1	21.1	19.8
1982	16.7	12.4	43.3	50.6	21.7	19.6	9.70	15.8	8.20	8.39	25.1	40.1
1983	21.3	21.5	23.4	30.0	21.4	13.1	5.69	5.24	7.40	9.60	18.6	24.0
1984	19.5	38.4	26.1	17.1	26.7	12.7	7.56	5.03	6.47	8.05	13.1	24.4
1985	18.1	34.0	45.5	32.8	11.2	5.66	4.37	9.74	12.1	28.1	55.2	33.5
1986	31.3	22.8	43.7	21.3	15.5	9.29	8.73	5.90	43.0	45.2	17.6	16.8
1987	12.9	13.5	16.6	19.0	9.14	6.50	5.18	21.5	17.2	22.5	23.0	39.1
1988	26.6	29.1	32.6	38.6	15.1	5.34	3.61	3.56	5.12	12.5	36.7	26.4
1989	22.3	16.6	29.5	20.9	13.7	17.0	5.17	7.58	5.66	5.44	9.07	8.02
1990	19.5	18.0	25.9	18.8	35.6	15.6	7.48	5.42	6.79	14.9	24.9	22.0
1991	20.7	20.7	35.8	40.0	18.5	10.2	6.23	7.30	6.47	24.7	39.2	40.5
1992	24.1	25.3	34.6	30.6	14.0	7.06	9.70	5.66	5.90	9.26	31.7	22.0
1993	25.4	14.8	26.3	44.3	22.3	23.6	11.5	8.61	12.2	12.0	13.7	12.7
1994	9.69	20.8	33.6	20.9	13.6	10.7	17.6	10.9	7.21	11.4	26.2	17.7
1995	24.9	16.0	21.6	21.2	17.5	8.15	7.19	10.2	5.33	7.35	20.5	15.9
1996	18.1	25.3	19.3	18.8	18.3	23.3	9.31	5.82	4.31	7.18	9.28	14.7
1997	26.8	35.9	31.3	18.6	19.6	10.3	5.89	4.95	5.87	5.40	8.70	7.33
1998	13.4	17.3	22.9	23.6	10.7	7.22	3.59	5.06	4.15	7.23	9.15	8.99
1999	14.5	14.3	10.2	22.3	16.7	9.17	6.82	4.97	3.68	4.94	5.06	7.21
2000	7.98	9.49	10.5	20.4	26.5	16.1	6.96	4.79	6.29	6.08	11.3	10.3
2001	11.0	27.8	19.0	29.8	31.4	16.4	5.17	4.34	4.97	14.0	13.4	15.1
2002	14.5	17.4	23.4	23.2	19.3	11.0	4.67	5.10	3.84			
Mean of monthly streamflows	**18.0**	**20.7**	**29.1**	**27.4**	**19.0**	**12.1**	**6.87**	**7.84**	**8.31**	**13.0**	**17.6**	**19.4**

Figure 13. Average Monthly Flow Rates for Bear Creek at Getty St. – Data from USGS gauging station



2.8 Areas of biodiversity – Special Resources

The ecosystem types in the Bear Creek and Bear Lake Watershed support a diverse population of flora and fauna, and provide excellent opportunities to study, explore, and enjoy nature. Much of the middle and upper portions of the watershed provide habitat of irreplaceable value. There are few parcels of public land in the watershed and effort must be made to preserve the watershed's overall rural character in order to increase habitat and improve water quality. As a result from the increase of subdividing land parcels to smaller sizes, there is a need for action to ensure the connectedness of unique resources in the watershed. The green infrastructure plan created by Conservation Design Forum as part of the Stormwater Management portion of this Watershed Management Plan identifies areas of particular importance and vulnerability due to soil types (see Appendix C). In addition to acting as a valuable resource for stormwater management issues in the watershed, the green infrastructure portion of the stormwater management plan will work to keep the riparian corridor intact and thereby ensuring the preservation of water quality and habitat availability in the Bear Creek and Bear Lake Watershed. One of the general overarching goals of the Bear Creek and Bear Lake Watershed Project is to protect Bear Creek and its tributaries and manage them through public and private partnerships in such a way that will create a high quality natural, historical, and recreational resource and with a long range goal of providing the tools necessary to create a linked system of natural preserves, parks, and historical sites. Biking, hiking, horseback riding, wildlife viewing, and other recreational activities are just a select few of the opportunities that would be made available with ecologically sound land use decisions that ensure the preservation of the Bear Creek Watershed's unique natural resources.

Below is a table listing all of the known occurrences of threatened, endangered, and special concern species within the Bear Creek & Bear Lake watershed as well from the lower Muskegon River Watershed which includes the lower portion of the Bear Creek Watershed. The species and community information is derived from the Michigan Natural Features Inventory (MNFI) database. The listing is based on the GIS representation of the occurrences. Consequently any single occurrence may span watershed boundaries and be listed in more than one watershed. This list is based on known and verified sightings of special concern, threatened, endangered, and recently extinct species and represents the most complete data set available to date. It should not be considered a comprehensive listing of every potential species found within the watershed. Due to the inherent difficulties in surveying for special concern, threatened, and endangered species and inconsistency of inventory effort across the State, species may be present in a watershed and not appear on this list (MNFI, 2003).

Table 4. Species of Concern, Threatened, and Endangered Species within the Bear Creek & Bear Lake Watershed

Scientific Name	Common Name	State Status
Arabis missouriensis var deamii	Missouri rock-cress	Special Concern
Armoracia lacustris	Lake cress	Threatened
Asclepias hirtella	Tall green milkweed	Threatened
Sisyrinchium atlanticum	Atlantic blue-eyed-grass	Threatened
Trichostema dichotomum	Bastard pennyroyal	Threatened
Eleocharis melanocarpa	Black-fruited spike-rush	Special Concern
Cirsium pitcheri	Pitcher's thistle	Threatened
Clemmys guttata	Spotted turtle	Threatened
Clemmys insculpta	Wood turtle	Special Concern
Clonophis kirtlandii	Kirtland's snake	Endangered
Dendroica discolor	Prairie warbler	Endangered
Hemicarpha micrantha	Dwarf-bulrush	Special Concern
Elaphe obsoleta obsoleta	Black rat snake	Special Concern
Euxoa aurulenta	Dune cutworm	Special Concern
Fuirena squarrosa	Umbrella-grass	Threatened
Linum sulcatum	Furrowed flax	Special Concern
Haliaeetus leucocephalus	Bald eagle	Threatened
Cirsium hillii	Hill’s thistle	Special Concern
Lycaeides Melissa samuelis	Karner blue butterfly	Threatened
Lycopodium appressum	Northern prostrate clubmoss	Special Concern
Rhexia virginica	Meadow-beauty	Special Concern
Mikania scandens	Climbing hempweed	Extinct
Polygala cruciata	Cross-leaved milkwort	Special Concern
Psilocarya scirpoides	Bald-rush	Threatened
Pycnanthemum verticillatum	Whorled mountain-mint	Special Concern
Rhynchospora macrostachya	Tall beak-rush	Special Concern
Sistrurus catenatus catenatus	Eastern massasauga	Special Concern
Strophostyles helvula	Trailing wild bean	Special Concern
Terrapene carolina carolina	Eastern box turtle	Special Concern
Triphora trianthophora	Three-birds orchid	Threatened
Utricularia subulata	Zigzag bladderwort	Threatened
Zizania aquatica var aquatica	Wild-rice	Threatened

Chapter 3 Water Quality Problems / Designated and Desired Uses In The Bear Creek and Bear Lake Watershed

3.1 Water Bodies Impacted

The Bear Creek & Bear Lake Watershed and its supporting lakes and tributaries are the water bodies targeted in this Watershed Management Plan. The Bear Creek & Bear Lake Watershed is located in west-central Michigan and is approximately 11.5 miles long from its start in Dalton Township down to its mouth at Bear Lake channel to the Muskegon Lake AOC. Muskegon Lake then flows into Lake Michigan at the Muskegon Lake Channel. The Bear Creek & Bear Lake Watershed covers a land area of 19,058 acres. It is oriented in a northeast to southwesterly direction. The watershed lies entirely within Muskegon County and is shared by five local governments: Dalton Township, Laketon Township, Cedar Creek Township, Muskegon Township, and the City of North Muskegon. There are nine tributaries that flow into Bear Creek, including Little Bear Creek and 3 tributaries that flow directly into Bear Lake. The primary tributaries include Little Bear Creek, Ribe Drain, Furman Drain, Brandstrom Drain, Pillon-Staple, and Putman-Bard. There are a total of 16 subbasins that make up the watershed (Figure 2).

The following sections discuss the potential and known problems / threats to the designated and desired uses in the Bear Creek/ Bear Lake Watershed. This Management Plan only covers non-point source pollutants (NPS) in the Bear Creek & Bear Lake Watershed. However, several point source pollution sites, along with the toxic substances they contribute, will be mentioned and briefly described in hope of drawing additional attention to these critical areas. Additional research of the impact NPS and point source pollutants have on the watershed along with recommendations for restoration will be needed in the future. The Beneficial Use Impairments (BUIs), toxic substances, and NPS pollution in the Muskegon Lake Area Of Concern (AOC) are addressed through the Muskegon Lake Remedial Action Plan. This is discussed in more detail in section 3.3.

3.2 Designated Uses in the State of Michigan

All of Michigan's water bodies are protected by Water Quality Standards for specific designated uses defined by the Michigan Department of Environmental Quality (MDEQ). To protect water quality, Michigan has developed Water Quality Standards pursuant to Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (MDEQ 2002). In Michigan all surface waters are designated for and shall be protected for all nine of the following uses: Agriculture,

Industrial water supply, Public water supply at the point of intake, Navigation, Warm-water or Coldwater fishery, Other indigenous aquatic life and wildlife, Partial body contact recreation, and Total body contact recreation between May 1st and October 31st (see Table 5). These designated uses and criteria are designed to protect the public's health and welfare, to enhance and maintain the quality of water, and to protect the state's natural resources (MDEQ 2002).

Table 5. The State of Michigan's Designated Uses for Surface Waters

Designated Use	Description
Agriculture	Water supply for farmland irrigation and livestock
Industrial Water Supply	Water utilized in industrial practices
Public water supply at the point of intake	Safe public drink water
Navigation	Capable of supporting navigation of waterways
Warmwater / Coldwater Fishery	Supports life cycles of warmwater or coldwater fish
Other Indigenous Aquatic Life and Wildlife	Supports life cycles of other indigenous plants, animals, and insects
Partial Body Contact Recreation	Maintains water quality for recreational activities i.e., boating, skiing, canoeing, wading
Total Body Contact Recreation	Maintains water quality for recreational activities i.e., boating, skiing, canoeing, wading

If a body of water or stream reach is not meeting the water quality standards set for a specific designated use, then it is said to be impaired or in 'nonattainment'. If the body of water or stream reach is currently meeting these standards but is under the threat of not meeting those standards in the future, it is said to be 'threatened'. An annually published listing of the bodies of water and stream reaches in the state that are in nonattainment can be found in the MDEQ's Section 303(d) Report (MDEQ 2002). The MDEQ performs a rotating watershed cycle for surface water quality monitoring where each of the state's 58 major watersheds is scheduled for monitoring at least once every five years.

The Bear Creek & Bear Lake Watershed was monitored in the summer of 2001. It was included in the Muskegon River 303(d) cycle, as a subwatershed of the Muskegon River. Monitoring was done on Bear Lake but was limited on Bear Creek and its tributaries. Bear Lake is on the 303(d) list for non-attainment due to fish consumption advisories (FCAs), excessive polychlorinated biphenyls (PCBs), mercury, nutrient enrichment, and nuisance algal growths (MDEQ 2002).

3.3 Muskegon Lake Area Of Concern

As part of the Great Lakes Water Quality Agreement, United States and Canadian officials have identified, described, and evaluated 43 specific locations in the Great Lakes that have serious water quality problems causing known impairments to the beneficial uses of the area. These specific areas have been designated Areas Of Concern (AOC) (MCD - MLPAC 2002). In Michigan there are 14 AOCs, one of which is Muskegon Lake (Figure 14). This Management Plan will aid in the restoration and future stewardship of Bear Creek and Bear Lake which flow directly into the Muskegon Lake AOC.

The Great Lakes Water Quality Agreement calls for three stages of remedial actions: 1) Problem identification, 2) Identification of the actions necessary to restore beneficial uses and a strategy for tracking progress, and 3) Documentation that beneficial uses have been restored. The Remedial Action Plan (RAP) has been developed for Muskegon Lake and was most recently updated in 2002 in order to address theses necessary actions.

Figure 14. Areas of Concern in the Great Lakes Basin

Source –Canadian Remedial Action Plans

3.3.1 Muskegon Lake Remedial Action Plan/ Community Action Plan

The International Joint Commission (IJC) consists of representatives appointed by leaders in both Canada and the United States. In 1985, the IJC-Water Quality Board identified 14 Areas of Concern in Michigan, including Muskegon Lake. As a result of its AOC designation, a Remedial Action Plan was developed in 1987. This document was updated in 1994 and most recently in 2002. It is intended for use as a guide to facilitate continued interest and involvement for clean-up and preservation efforts by the public in Muskegon Lake (MCD - MLPAC 2002). The Remedial Action Plan identifies targets for restoration, indicators of success and actions to address the restoration of impaired beneficial uses throughout the Muskegon Lake AOC ecosystem. It also draws needed attention to the specific human actions that contribute to each impairment and therefore areas where community action is most needed. The 2002 RAP provided an updated and strategic approach to the 1994 RAP. The overall goal of the RAP is to restore the Beneficial Use Impairments (BUIs) and eventually de-list Muskegon Lake as one of the Great Lakes 43 Areas of Concern.

Table 6. Muskegon Lake's Beneficial Use Impairments

Beneficial Use	Impaired?
Restriction on human consumption of fish and wildlife	Yes
Loss of fish and wildlife habitat	Yes
Degradation of fish and wildlife populations	Yes
Degradation of benthos (bottom dwelling organisms)	Yes
Restrictions on dredging	Yes
Degradation of aesthetics	Yes
Beach Closings (health advisories)	Yes
Eutrophication or undesirable algae	Yes
Restrictions on drinking water consumption (groundwater)	Yes
Bird or Animal Deformities or reproduction problems	No
Degradation of phytoplankton & zooplankton populations	No
Tainting of fish and wildlife flavor	No
Fish tumors or other deformities	No
Added costs to agriculture or industry	No

As Muskegon Lake moves into the restoration of Beneficial Use Impairments (BUIs), the Muskegon Lake Public Advisory Council (MLPAC) will initiate final delisting of the Area of Concern. The final removal of Muskegon Lake as an AOC must meet specific

criteria determined by the MLPAC and move through formal approval by state, federal, and international agencies.

3.3-2 Point Sources of Pollution in the Bear Creek & Bear Lake Watershed

As stated earlier, the Bear Creek & Bear Lake Watershed Management Plan will not focus on point source pollution. This Management Plan covers only non-point source pollutants (NPS) in the Bear Creek & Bear Lake Watershed. However, there are two superfund sites in the watershed that were a significant source of pollutants and are worthy of mention. It is hoped that drawing additional attention to these sites will facilitate additional research of their impact on the watershed. In general toxic substance and NPS pollution in the Muskegon Lake Area Of Concern are addressed through the Muskegon Lake Remedial Action Plan (RAP).

Ott / Story / Cordova Site

The Ott / Story / Cordova site located in Section 32 of Dalton Township is a former organic chemical production facility that operated from 1957 until 1985. The facility used as many as five unlined seepage lagoons to dispose of industrial wastewaters and production vessel residues. These practices resulted in contamination of groundwater, soils, and nearby Little Bear Creek and its unnamed tributary. Approximately 10,000 drums of waste material, some of which contained phosgene gas, were also stockpiled on-site. The former production area is approximately 20 acres in size, surrounded by wooded undeveloped land and a semi-rural residential area with approximately 300 to 500 residents in a one-mile radius of the site. See Figures 15 and 16 for Ott/Story/Cordova Site Maps.

Among the most dangerous contaminants present in the groundwater are: vinyl chloride, 1,1-dichloroethene, 1,2-dichloroethane; Present in the soils include: benzoic acid, 1,2-dichlorobenzene, 4-chloroaniline, 1,1,1- trichloroethane, xylene, toluene, 1,4-dichlorobenzene, hexachlorobenzene, 4,4'-DDT, dioxin; Present in Little Bear Creek: 1,1-dichloroethane (USEPA, 2002).

The state of Michigan and Cordova Chemical Co conducted a partial removal between 1977 and 1979. By that time, a contaminant plume containing at least 40 organic chemicals migrated approximately one mile to the southeast, contaminating Little Bear Creek and several private wells. Residents received bottled water until the 1982 installation of a municipal water system by potentially responsible parties (PRPs) in settlement of a citizens' suit. The U.S. Environmental Protection Agency (U.S. EPA) completed a Remedial Investigation/Feasibility Study (RI/FS) and signed a Record of Decision (ROD) on September 29, 1989, for groundwater containment by at least five extraction wells to be completed by September 30, 1998. A second ROD signed on September 29, 1990, requires aquifer restoration by using additional extraction wells and treatment by a Groundwater Treatment Facility (GWTF). On September 27, 1993, U.S. EPA signed a third ROD selecting Low Temperature Thermal Desorption as the remedy

Figure 15. Ott/Story/Cordova Superfund Site Index Map – Dalton Township

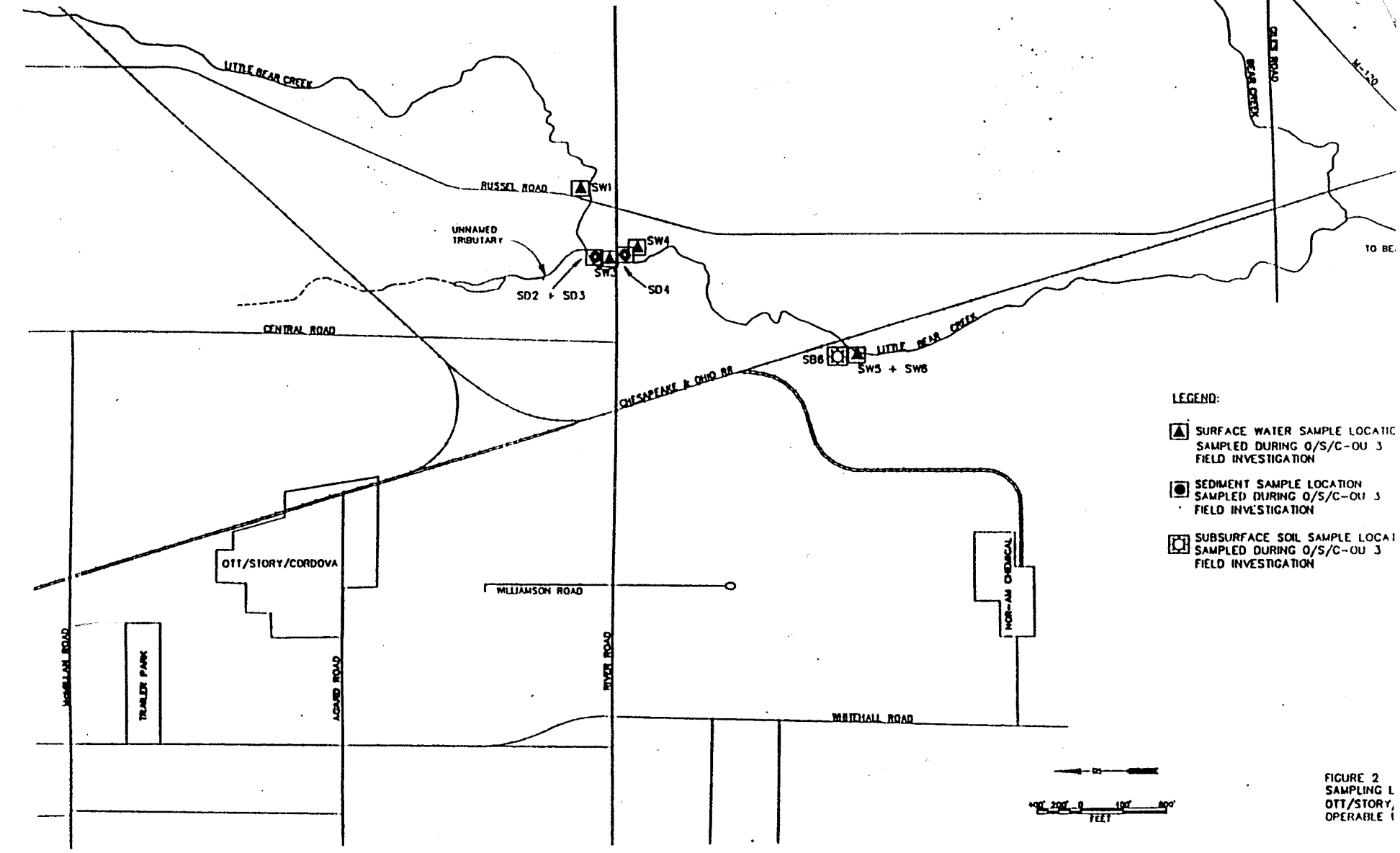


FIGURE 2
SAMPLING L
OTT/STORY,
OPERABLE

Figure 16. Ott/Story/Cordova Superfund Site Soil Contamination Levels Prior to Cleanup

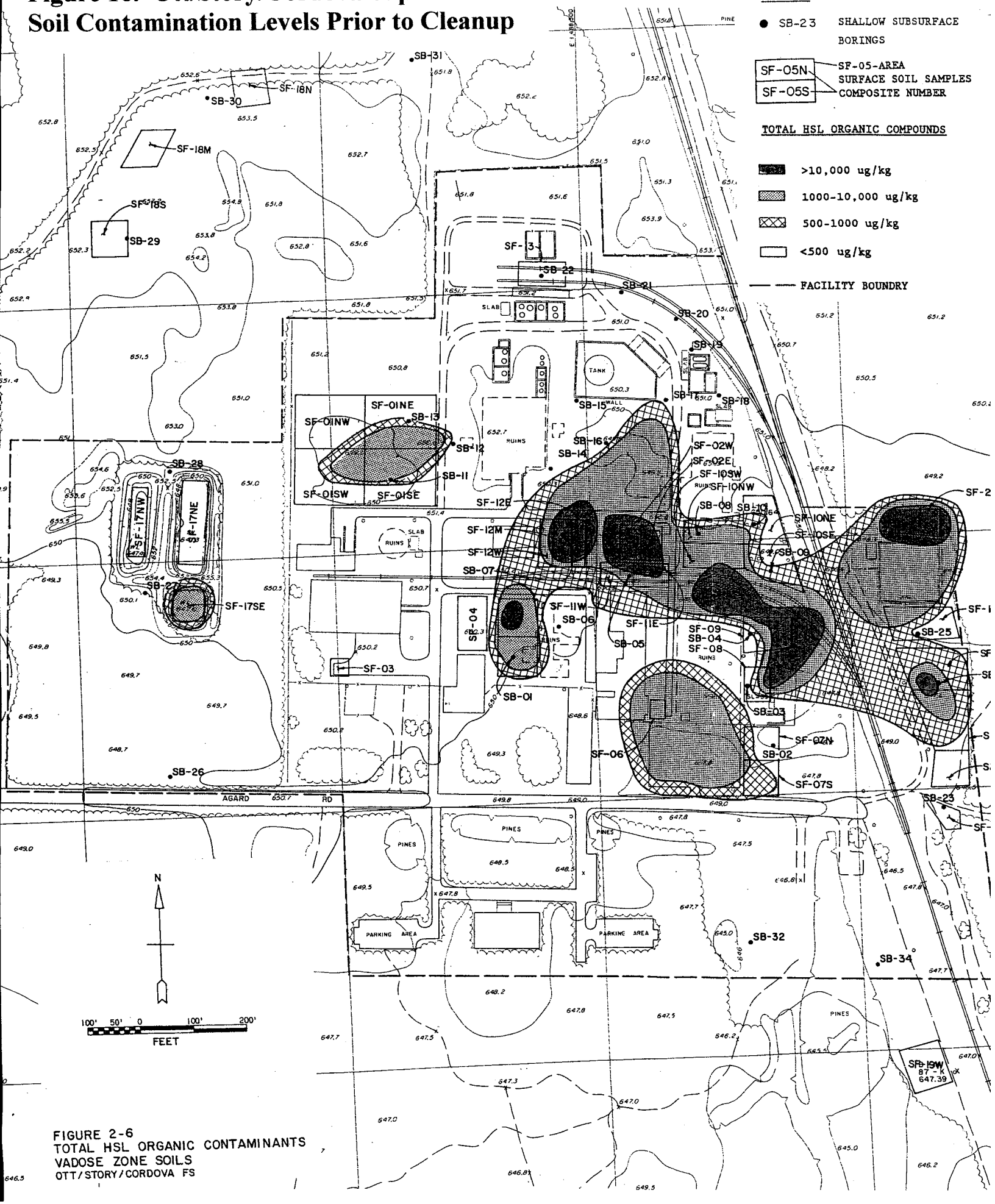


FIGURE 2-6
TOTAL HSL ORGANIC CONTAMINANTS
VADOSE ZONE SOILS
OTT/STORY/CORDOVA FS

for approximately 10,000 cubic yards of soil and sediment. A ROD Amendment for Creek monitoring and excavation and off-site disposal of approximately 4,000 cubic yards of that soil has been written and was signed on February 26, 1998. The soil cleanup was completed in October of 2002 under the authority of the State of Michigan. All cleanup activity has been done with federal funds. The GWTF design was completed on September 29, 1992 and started treating contaminated groundwater on February 24, 1996. It has removed approximately 5,400 pounds of contaminants from approximately 2.5 billion gallons of groundwater. System operational and functional status was achieved on September 14, 2000. The Long-Term Response Action (LTRA) started on that date to be complete by September 30, 2030. It is estimated that approximately 31,000 pounds of contaminant will be removed from approximately 14.5 billion gallons of water treated (U.S. EPA 2002).

Duell and Gardner Landfill

The 40-acre Duell & Gardner Landfill site located in Dalton Township was an operating municipal landfill from the 1940's to 1975. Before 1969 industrial waste and general refuse were accepted at the site. From 1969 to 1973 the landfill was operated as a licensed solid waste disposal facility. In 1971 the Michigan Department of Public Health (MDPH) stipulated that no liquid waste was to be disposed of in the landfill. However, in 1973 the MDPH noted that liquid waste disposal was occurring. Wastes were deposited on the soil surface and in surface depressions. The landfill ceased operations in 1975.

Volatile organic compounds (VOCs) including chloroform, carbon tetrachloride, aniline, and N, N-dimethylaniline have been detected in on-site groundwater. PCBs, crystal violet, aniline, and N,N-dimethylaniline were detected in on-site soil. Potential health risks may exist for individuals who have direct contact with or ingest contaminated groundwater or soil.

Materials found on the site included approximately 500 drums in various stages of deterioration, hundreds of laboratory bottles, areas of refuse and debris, and piles of unidentified sludge-like material. Volatile organic compounds (VOCs) including chloroform, carbon tetrachloride, aniline, and N, N-dimethylaniline have been detected in on-site groundwater. Polychlorinated biphenyls (PCBs), crystal violet, aniline, and N,N-dimethylaniline were detected in on-site soil. Potential health risks may exist for individuals who have direct contact with or ingest contaminated groundwater or soil. Approximately 140 people live within a one-mile radius of the site (USEPA 2002).

In 1986, under Federal authority, U.S. Environmental Protection Agency (USEPA) removed approximately 550 drums, the laboratory bottles, sludge-like material, and general refuse and debris. The site was posted to reduce the potential for exposure to remaining contaminants. In December of 1986 the state began an investigation to determine the type and extent of groundwater and soil contamination that remained on site and to identify alternative technologies for the cleanup. Based on the results of the investigation, a remedy which includes low-temperature treatment of contaminated soil, carbon adsorption treatment of groundwater, and capping of the landfill was selected in the Fall of 1993. A Unilateral Administrative Order (UAO) was issued by USEPA on June 22, 1994. The potentially responsible party (PRP) (CPC International) began design

of the remedy in 1994. In July 1999, PRP ceased all work after receiving a favorable legal decision on the issue of its underlying liability at the site. Currently, the USEPA and the State of Michigan are addressing the remaining clean-up through Superfund Financed action. Pre-design work indicated that approximately 200 cubic yards of contaminated soil remains. Pre-design groundwater investigations concluded that the contaminant concentrations have declined and have not migrated from the site. Based on these findings, a Record of Decision (ROD) amendment will be done to include soil excavation, with off-site disposal, groundwater, and consolidation of landfill materials and capping. The Remedial Action was complete in 2001 (USEPA 2002).

3.4 Bear Creek & Bear Lake Impacted Designated Uses

Resulting from focus group and project technical team meetings, four of the nine designated uses for the Bear Creek & Bear Lake Watershed were determined to be 'impaired' or in non-attainment. In addition, two of the State designated uses in the watershed are currently 'threatened'. Threatened water bodies and associated uses, are defined as those that currently meet water quality standards but are under the threat of not meeting those standards in the future. The Bear Creek/ Bear Lake Watershed Management Plan will focus on both the threatened and impaired designated uses in order to maintain water quality and restore the designated uses throughout the watershed. The impaired designated uses include: Coldwater Fishery, Aquatic Life and Wildlife, Partial Body Contact Recreation, and Total Body Contact Recreation. The impaired and threatened uses were ascertained through a combination of field inventories of suspected pollutants, technical team meetings/correspondence, MDEQ surveys, and water quality reports.

Table 7. Designated Uses In The Bear Creek & Bear Lake Watershed

Designated Uses	Non-attainment (Impaired) or Threatened status
Cold-Water Fishery	Non-attainment/Impaired
Aquatic Life and Wildlife	Non-attainment/Impaired
Partial Body Contact Recreation	Non-attainment/Impaired
Total Body Contact Recreation	Non-attainment/Impaired
Warm-Water Fishery	Threatened (*to be protected*)
Navigation	Threatened (*to be protected*)
Agriculture	Attainment
Industrial Water Supply	Attainment
Public Water Supply	Attainment

For each State designated use there are a number of pollutants that are impairing the use, listed in Table 8 below. These are pollutants that adversely, or have the potential to, affect the designated use listed in the first column. There are sources for each pollutant,

and causes for each source that are described in detail in the Final Water Quality Statement (Chapter 3.9).

Table 8 also notes the certainty of specific pollutants in the watershed. Pollutants are listed as being either known, suspected, or potential. Examples to determine the certainty of a specific pollutant and its source include performing road/stream crossing inventories, and streambank surveys. It should be noted that this is a general list that describes situations over the entire watershed. Not all reaches in the Bear Creek / Lake Watershed are impacted by all of the listed pollutants below and all known pollutants have been verified by MDEQ, MCD, and volunteer field observations.

Table 8. Pollutants Affecting Designated Uses for the Bear Creek / Lake Watershed

Designated Use to be Restored, Improved, or Protected	Pollutants Known (k), Suspected (s), or Potential (p)
Coldwater Fishery- Restored	Sediment - (k) Nutrients - (s) Temperature - (k) Toxic Substances - (k) Invasive Species - (s)
Aquatic Life and Wildlife -Restored	Sediment - (k) Nutrients - (s) Temperature - (s) Toxic Substances - (k) Invasive Species - (s)
Partial Body Contact Recreation - Restored	Fecal coliform and *E.coli - (k)* Nutrients - (s) Toxic Substances (k)
Total Body Contact Recreation - Restored	Fecal coliform and *E.coli - (k)* Nutrients - (s) Toxic Substances - (k)
Warmwater Fishery - Improved	Sediment - (k) Nutrients - (s) Temperature - (k) Toxic Substances - (k) Invasive Species - (s)
Navigation - Improved	Sediment - (k) Nutrients - (k) Invasive Species - (k)
Agriculture - Protected	Sediment - (k)
Public Water Supply - Protected	Sediment - (k) Invasive Species - (s) Toxic Substances - (k) Fecal coliform and *E.coli - (k)*
Industrial Water Supply - Protected	Sediment - (k)

3.5 Non-point Source Pollutants

The major water quality problems in the Watershed are: sedimentation, combined nutrient loadings from both point and non-point sources, toxic substances, and elevated stream water temperatures which all severely impact water quality in Bear Creek and Bear Lake. The Bear Creek/Lake Watershed Technical Team ranked the problems based on local observations of impact on the designated uses. Sediment was ranked as the highest priority because of the broad negative impacts associated with increased sedimentation, and the fact that nutrients as well as many toxic substances are attached to sediment. So by reducing sedimentation to the system, toxic substances and nutrients would also be reduced.

Sedimentation

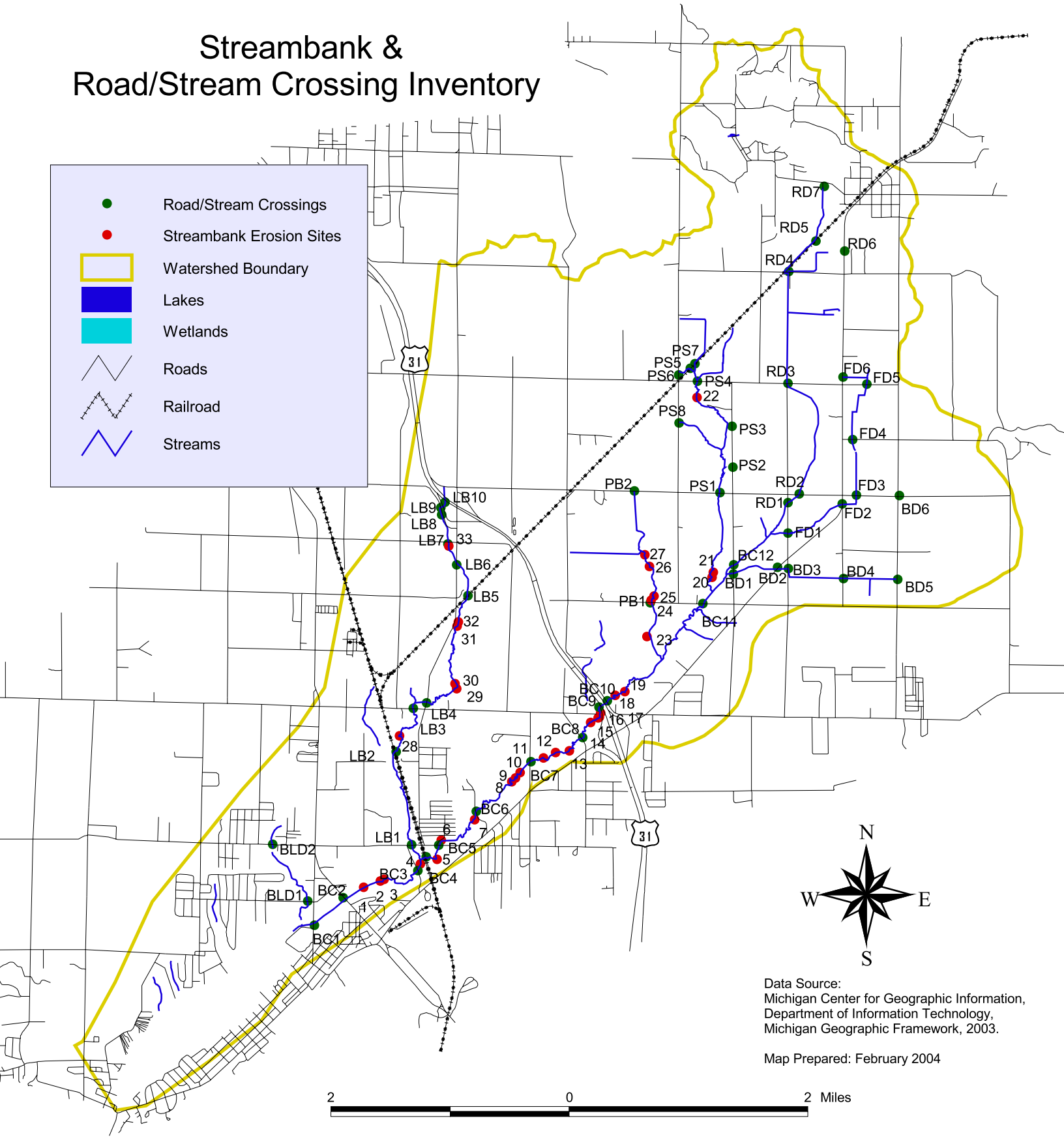
Excessive sedimentation and erosion is a major pollutant impairing the State designated uses in the watershed. Sources of sediment in the Bear Creek and Lake Watershed include streambank erosion, construction sites, road/stream crossing sites, and erosion from agricultural cropland. Though erosion is a naturally occurring process, the effects of accelerated erosion and sedimentation can have devastating impacts on aquatic ecosystems by degrading habitat and decreasing biodiversity. When the suspended sediment in the water column settles out it covers gravel, rocky, and woody habitat areas thereby leading to decreases in habitat diversity and aquatic plant production. The loss of steam habitat diversity limits the areas where fish can spawn and also limits the amount and variety of food in the stream (macroinvertebrates or aquatic insects). Sediment in the stream comes from natural disturbances and weathering, but is accelerated by traditional human land management activities. The success of coldwater fish in Bear Creek has been limited as a result of this lack of habitat. According to MDNR Fisheries Division Biologist Richard O'Neal, Little Bear Creek and upstream reaches of Little Bear Creek, are designated coldwater trout streams but trout abundance is low due to the aforementioned degraded habitat conditions.

Sediment accumulating at the Bard Road Stream crossing

Drainage ditch bank collapse contributing large amounts of sediment to the system

Stream bank erosion occurs as a result of hydrologic fluctuations, recreational access, livestock access to the stream, lack of riparian vegetation, and increases in flow rates due to stormwater inputs. An inventory of erosion on Bear Creek, Little Bear Creek and their tributaries has been conducted, identifying 33 Sites (Figure 17). Streambank erosion occurs in natural sections as well as in highly

Figure 17. Bear Creek & Bear Lake Watershed



maintained stretches such as backyards and county drains. By using a variety of Best Management Practices (BMPs), sediment input to Bear Creek and Bear Lake will be drastically reduced.

Due to the numerous agricultural drains in the upper portion of the watershed, many contributions of small amounts of wind and water erosion from active and old fields combines to have a negative impact on Bear Creek and eventually Bear Lake. The majority of the upper portion of the watershed has been historically drained because of the high groundwater table. These ditches are frequently maintained to deter vegetation from establishing on their steep banks resulting in increased velocity and potential to contribute erosion to the stream reaches. While some erosion processes are naturally occurring in the watershed, and significant amounts of sediment are being moved as a result of natural denudation, it is still feasible to manage and control excessive sediment loadings that have resulted from human land use activities.

In an effort to evaluate the road/stream crossings in the Bear Creek & Bear Lake Watershed a complete Road/Stream Crossing Inventory was conducted. 53 stream crossings were identified (Figure 17, road stream crossing map). Road / stream crossings represent vulnerable areas where high potential for negative impacts to water quality to exist. All road/stream crossings were prioritized based on severity and are detailed in the Bear Creek Stream Inventory, Appendix B.

Construction sites have a high potential to contribute sediment to Bear Creek, Little Bear Creek and their tributaries. Improper use of erosion control practices or the lack of proper excavation increases the probability of sediment loads entering the watercourse. Enforcement of erosion control laws is necessary to comply with water quality standards and to restore and improve the designated uses of the Bear Creek Watershed.

Nutrient Loading

Nutrient sources in the Bear Creek and Lake Watershed include residential, commercial, agricultural, stormwater, animal waste runoff, and failing or poorly maintained septic systems. Excess nutrients such as nitrogen and phosphorus contribute to increased growth of rooted aquatic plants and algae (floating and filamentous). Excessive plant growth in Bear Lake has reduced the number and the suitability of fish beds and other aquatic habitats necessary to support a wide variety aquatic life. In addition, the growth and amount of cover that these plants supply for smaller fish and aquatic life may inhibit the ability of larger fish to find prey, thus reducing the abundance of large mature fish in the system. A low oxygen environment is created as microorganisms and bacteria feed on decaying plant matter. Therefore excess plant growth, caused by excess nutrients, contributes to further reduction in dissolved oxygen content further degrading aquatic habitat conditions. The excessive nutrient loading of the Bear Creek and Bear Lake Watershed is contributing to the non-attainment status of the cold-water fishery, partial and total body contact, and navigation designated uses.

The dense plant beds and algal blooms that result from excessive nutrients can restrict use of boats and personal watercraft. These dense plant beds make it difficult to navigate some areas of the lake due to the strain that they put on boat motors.

Toxic Substances

Many different toxic substances may contaminate water bodies through sources such as municipal and industrial discharges, unlined landfills, and runoff from urban or agricultural land. In addition, there is widespread atmospheric mercury deposition into most of Michigan's surface waters. Mercury is of high concern because it bio-accumulates and is shown to be hazardous to wildlife and human health. Mercury is found in nature, but is also released by burning wastes and coal, and the improper disposal of mercury containing products such as thermometers, batteries, and old thermostats. Small amounts can dissolve in water but bacteria can change it into a more toxic form called methyl mercury. Fish pick it up as they feed and also absorb it as water passes over their gills. Larger fish accumulate more as they eat other fish. As a result of this bioaccumulation there is a statewide mercury-based fish consumption advisory that is applied to all of Michigan's inland lakes (MDNR 2002).

Stormwater outlet into Bear Creek At Witham Rd.

Stormwater and urban runoff, containing oils, grease, and solids is an ever increasing concern in the Bear Creek & Bear Lake Watershed. Impervious surfaces in urbanized areas of the watershed contribute to toxic substances during storm events when water runs off streets, parking lots, and roofs and enters storm drains leading to Bear Creek, Lake, and any of their tributaries.

Thermal Pollution

Thermal pollution is the warming of the water temperature to a degree that limits the amount of dissolved oxygen available for use by aquatic life. Fish are cold blooded so their body temperature is generally close to the temperature of the water that surrounds it. When the water temperature increases, so does the temperature of the fish, this will increase the metabolic rate and other physical or chemical processes as well. When thermal stress occurs, fish cannot efficiently meet these energetic demands (Diana 1995)(MR 319). The primary impact on stream temperatures results from the removal or reduction of streamside or shoreline vegetation that exposes the water surface to direct solar radiation by day and the open sky at night (Satterlund & Adams, 1992). The

Drainage ditch with very little canopy cover contributing to thermal pollution

installation of vegetated shoreline and streamside buffers also help by increasing canopy cover and providing streambank stabilization. Buffers act as a filter trapping excess nutrients and other pollutants before they enter the water.

The Bear Creek and Bear Lake Watershed is characterized by a high groundwater level. As the desire to develop and farm the land in the upper portion of the watershed increased, a system of drainage ditches were created to lower the water table therefore making the land more suitable for more intensive uses. The majority of these drains are frequently maintained to deter vegetation from establishing and therefore act as vectors of thermal pollution to the mostly groundwater fed river system. In addition, stormwater outfalls in the more developed lower end of the watershed and along the M-120 corridor, contribute to the problem of thermal pollution. When rain falls onto hot rooftops, parking lots, or streets it quickly warms as it is directed toward storm-sewers, which directly output into Bear Creek or its tributaries. The result is an increase in water temperature and decrease habitat suitability for the coldwater fishery. There are many management practices that should be implemented to slow the release of stormwater which will improve water quality and will work toward the goal of restoring the coldwater fishery designated use (see Appendix C, Bear Creek and Bear Lake Watershed Stormwater Management Plan).

3.6 Desired Uses in the Bear Creek & Bear Lake Watershed

Based on input from focus group meetings held within the watershed held in the spring of 2002, community residents and the Bear Creek & Bear Lake Watershed Steering Committee identified several desired uses for the watershed. Desired uses are based on factors important to the watershed community. They may include current or potential natural resource concerns. Although they might not have direct impact on water quality, they are important because they will help to encourage community support for overall project activities (MSU 2000).

Table 9. Desired Uses Within the Bear Creek & Bear Lake Watershed

Desired Uses	Goal
Groundwater / Drinkable Water	Ensure groundwater and surface water quality throughout Bear Creek & Bear Lake Watershed
Unique Habitat	Identify critical habitat for endangered / threatened species and ways to protect their habitat
Open Space	Establish permanent easements and nature preserves within the watershed
Pollution sites / Safety within	Clean up polluted areas
Public access / Recreation	Establish access sites along Bear Creek and Bear Lake

3.6-1 Groundwater / Drinking Water

The majority of the residents within the watershed depend on ground water for their drinking water, therefore it is well understood that the quality of groundwater is of utmost importance. As a result, the residents of the Bear Creek & Bear Lake watershed have stated groundwater / drinking water as a desired use of the watershed. In order to ensure high water quality, efforts must be taken to locate and then remove sources/avenues of pollutants that may threaten the use of the ground water for safe drinking.

The water quality summary portion of the Bear Creek & Bear Lake Management Plan focuses on state designated uses, one of which is public water supply at the point of intake (see Sections 3.4 and 3.9). The Water Quality Summary will be used as a reference to distinguish where major sources of pollutants are located within the watershed and therefore what actions need to be taken to ensure the preservation of groundwater / drinking water quality as a desired use. It is imperative that there be ongoing annual sampling and testing of the groundwater / drinking water in the watershed. Consistent testing of the water supply will create necessary data which could be used to indicate water quality and eliminate any potential health risks.

3.6-2 Unique Habitat

Residents indicated that the location and designation of critical areas that may support endangered or threatened species was a desired use of the watershed. The Bear Creek and Bear Lake watershed as a whole is experiencing significant population growth. Census data show that from 1990 to 1995 a 5.6% increase in the number of residents within the watershed took place (see Chapter 2.5). As a result there is more pressure than ever before on remaining open spaces, wetlands, and other waterways within the watershed. In order to maintain the presence of unique habitat as well as provide for this desired use, critical habitat for endangered species must be identified and preserved. There are several endangered species and species of special concern found within the watershed. As a part of this Watershed Management Plan, areas of biodiversity were located and discussed in Chapter 2.8. It should be pointed out that the Bear Creek and Bear Lake Watershed Management Plan project did not focus on locating areas of biodiversity. Nevertheless, the efforts conducted in the creation of this plan will shed

needed light on areas that are essential to the overall biodiversity and integrity of the Bear Creek and Bear Lake Watershed. The hope is that the Bear Creek and Bear Lake Watershed Management Plan will provide the stimulus for future research of these unique species and their habitats and effective ways to preserve their interconnectedness.

3.6-3 Open Space

As pointed out earlier, the Bear Creek & Bear Lake Watershed is experiencing significant population growth. Along with this population increase comes a need for water, water treatment, wastewater management, storm water management, roads, and other impervious surfaces. All of these uses put more and more pressure on the watershed's open spaces. There are still open spaces that remain but with the population growth and expansion, they are disappearing quickly. Many of the watershed residents recognize this desire that open spaces be preserved for themselves and for future generations to enjoy.

A critical component of the Bear Creek and Bear Lake Management Plan is the assurance of land use congruency between local governmental units. Langworthy, Strader, Leblanc, and Associates, Inc.(LSL) was contracted by the Muskegon Conservation District to help local municipalities update land use master plans, develop alternative ordinance language recommendations, and to create the Site Plan Review Guide (SPR). LSL developed alternative zoning ordinance language for water quality and open space protection for the local units of government in the watershed. LSL created the Site Plan Review Guide (SPR, Appendix E) for local planning commissions and legislative bodies to assist them in the difficult process of reviewing site plans, and to tailor that process toward the protection of open space and rural character. LSL also assisted a study done by the Hydrologic Studies Unit of the MDEQ, to conduct a build-out analysis of the watershed. The build-out analysis provides information for modeling the potential effects to water quality resulting from various land use scenarios. Additionally, the build-out analysis and Hydrologic model was utilized in the production of the Stormwater Management Plan (Appendix C). LSL's work will help to guide future growth in a sensitive manner and will aid in the effort to meet the watershed community's desired uses and protect natural resources. Through these practices it is suspected that open spaces will be preserved.

3.6-4 Pollution Sites / Safety Within

There are two superfund sites within the Bear Creek & Lake Watershed, the Ott / Story / Cordova Chemical site and the Duell and Gardner Landfill (see Chapter 3.3). Watershed residents have demonstrated that they desire pollution sites within the watershed to be cleaned up. By its design, the Bear Creek & Bear Lake Watershed Management plan only covers nonpoint source pollutants. However, as stated earlier, several point source pollution sites, along with the toxic substances they contribute, were mentioned and described in hopes of drawing additional attention to these critical areas and additional research of there impact on the watershed and direction for restoration in the future. Toxic substances and nonpoint source pollution in the Muskegon Lake Area Of Concern are addressed through the Muskegon Lake Remedial Action Plan. This is also discussed in more detail in section 3.3.

As part of the Bear Creek & Bear Lake Watershed Management Plan, critical areas were identified. A critical area is the geographic portion of the watershed that is contributing a majority of the pollutants and is having a significant impact on the water body (MDEQ 2000). The concept behind identifying critical areas is to reduce the geographic scope of the watershed management plan and focus needed attention on the part of the watershed that is contributing pollutants to the watershed. Pollution sites within the watershed should be given a high priority in the implementation of this management plan. The act of prioritizing critical areas in the watershed allows managers to achieve the greatest pollutant reduction while treating the fewest sources, leading to the greatest water quality benefit for the funds available.

3.6-5 Public Access / Recreation

The residents of the Bear Creek & Bear Lake Watershed have pointed out that public access / recreation is a desired use of the watershed. There are several access points to Bear Lake in the form of boat launches, city parks, and from Muskegon Lake through Bear Lake Channel, but there are no public access points to Bear Creek. It is a goal of this plan to draw attention toward this desired use with the hopes of creating public access points and increased recreation opportunities along both Bear Creek and Bear Lake.

It may be that as a result of the lack of pubic access to Bear Creek, people have developed an apathetic view of the river and its protection. It is possible that the lack of access has denied the citizens of the watershed the opportunity to develop a relationship between the river and themselves. This relationship would facilitate better stewardship of the resource by cultivating care for its' natural integrity. Providing public access points to Bear Creek and Bear Lake may be an important factor in gaining community support for overall conservation practices and stewardship of the Bear Creek & Bear Lake Watershed. It is concluded that in order for there to be increased support and interest in the conservation practices of Bear Creek and Bear Lake, public access points must be established. Increased access would allow for increased recreational opportunities in the form of canoeing, kayaking, fishing, wildlife viewing, etc. which would satisfy a desired use for the watershed.

3.7 Bear Creek and Bear Lake Watershed's Impaired Desired Uses

It is assumed that because the residents of the Bear Creek and Bear Lake Watershed desire specific uses for the watershed those uses are currently not being met. Although a community's desired uses may currently be met, it is assumed for the sake of planning and the development of the management plan for implementation activities, they are not. Therefore all of the watershed resident's desired uses of the watershed (Table 10) are impaired and need attention.

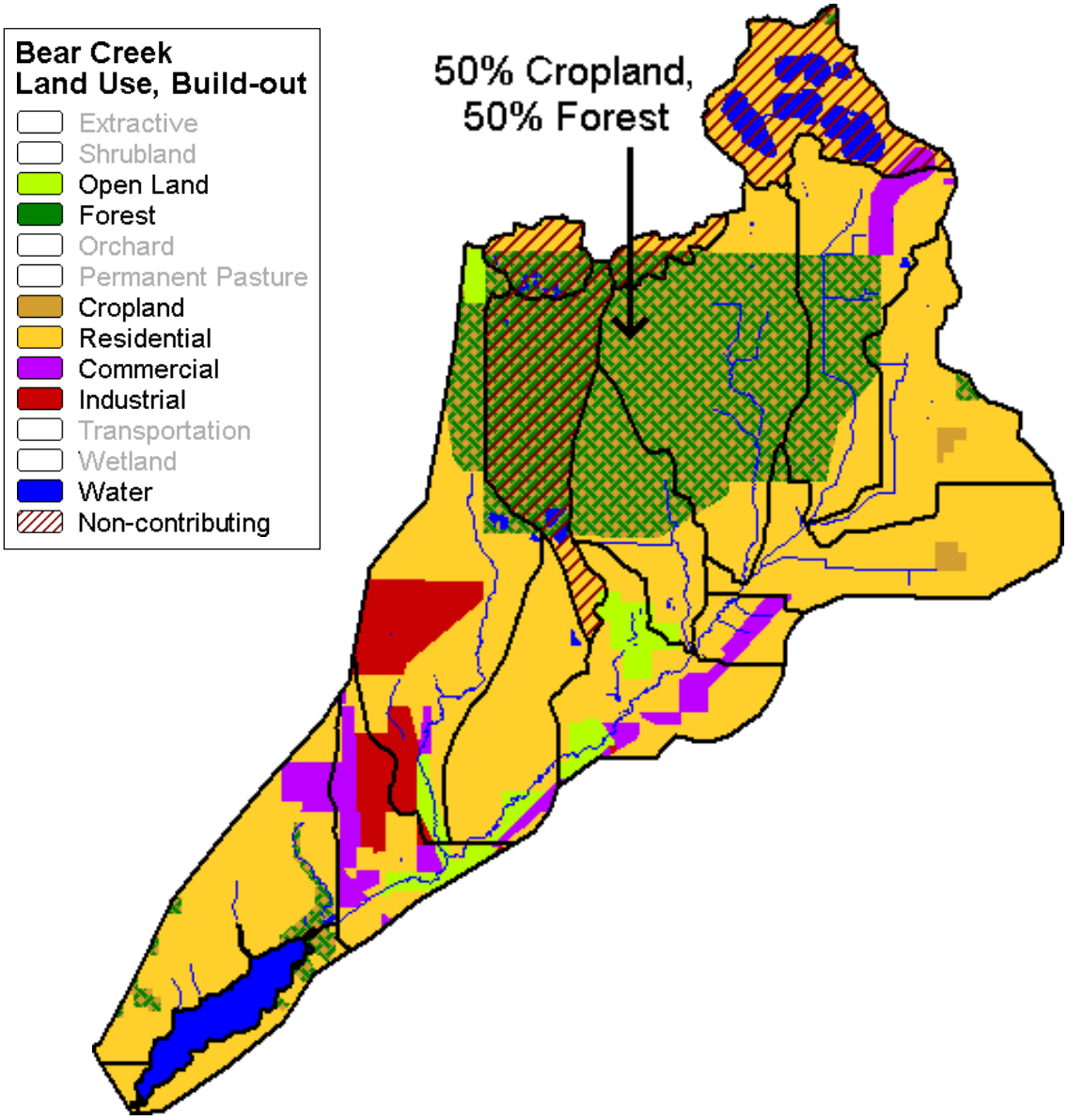
Table 10. Community Desired Uses in the Bear Creek and Bear Lake Watershed and Their Attainment Status

Desired Use	Impaired?	Goal
Groundwater / Drinking Water	Yes	To Ensure water quality throughout Bear Creek & Bear Lake Watershed
Unique Habitat	Yes	Identify critical habitat for endangered / threatened species and ways to protect their habitat
Open Space	Yes	Establish permanent easements and nature preserves within the watershed
Pollution sites / Safety within	Yes	Clean up polluted areas
Public access / Recreation	Yes	Establish additional access sites along both Bear Creek and Bear Lake

3.8 Build-Out Analysis

Based on land use zoning plans prepared by Langworthy, Strader, LeBlanc and Associates, Inc. and the build-out analysis conducted by the Michigan Department of Environmental Quality as part of their Hydrologic Study of the Bear Creek Watershed (Appendix F), extrapolation of current land use proportions and zoning designations were determined. Under a build-out scenario, the land uses were assumed to be developed to the maximum allowable under current zoning regulations. The build-out analysis was conducted to estimate the hydrologic impact and condition of the watershed under final expected land use conditions (Figure 18).

Figure 18. Build-Out Scenario of the Bear Creek and Bear Lake Watershed – Source MDEQ 2003



Although the build-out scenario map shows relatively significant areas that would remain as cropland/forest mix and some open lands, the majority of the watershed is shown to be developed. All remaining open lands are discontinuous and generally unconnected as visible in the build-out scenario map above. As population rates climb the need for impervious surfaces related to urban development increases and exposes the watershed to significant threats to water quality that would undoubtedly decrease the likely hood of restoring or improving State designated and community desired uses. To minimize these

impacts it is essential to implement ecologically sound, conservation-based land use plans and stormwater management techniques.

The "Bear Creek Watershed Hydrologic Study"(MDEQ, 2003) shows significant increases in runoff volume and peak flow rates from the 10%, 4%, and 2% chance (10-year, 25-year, and 50year), 24-hour storms. These increases would cause flooding problems unless mitigated through the use of effective stormwater management techniques. The projected increases from the 50% chance (2-year), 24-hour storm will increase channel-forming flows. Changes in hydrology that increase this flow can cause the stream to become unstable leading to excessive erosion (MDEQ 2003).

Little bear Creek and the main branch below McMillan Road currently have discharge rates less than 0.008 cfs/acre for the 2-year event, which was found to be the threshold flow rate for and unimpaired fishery in other area watersheds. However, under build-out conditions, essentially no areas would be below the fishery threshold discharge rate. However, all of the indicated increases assume that there will be no changes in development practices or ordinances to require detention and other stormwater management measures. The MDEQ's hydrologic analysis clearly demonstrates that steps must be taken to prevent increases in flow rates and volumes that would otherwise lead to increases in flooding, streambank erosion, and loss of the potential to support a trout fishery (CDF, 2004). These steps are also necessary to ensure the protection, and restoration of the State Designated Uses. For more information regarding flow rates under different build-out scenarios refer to Appendix F. A Hydrologic Study of the Bear Creek Watershed, and effective stormwater management recommendations and associated BMPs can be found in the Bear Creek and Bear Lake Stormwater Management Plan, Appendix C.

3.9 Final Water Quality Summary

The Comprehensive Watershed Management Table (Table 11) is based upon basic principals set by the Michigan Department of Environmental Quality (MDEQ) used to assess the condition of a watershed. It combines all the data listed in Tables 7 and 8 into one table for quick reference. The first column lists the designated use to be restored, improved or protected in the Bear Creek & Bear Lake Watershed. The second column lists the known, suspected, and potential pollutants to the designated use and the third column briefly describes the impacts the specified pollutant has on the designated use. The fourth column lists all known, suspected, and potential sources to the pollutants of concern and also demonstrates targets to act upon for watershed management. A detailed account of action items to be implemented to restore, improve, or protect the designated uses is listed in Chapter 8 Proposed Implementation Activities.

Table 11. Comprehensive Watershed Management Table Showing Sources of Pollutants impacting the Designated Uses in the Bear Creek and Bear Lake Watershed.

Designated Use to be Restored, Improved, or Protected	Pollutants of Concern Known, Suspected, or Potential	Impacts of Pollution on Designated Use	Source of Pollution Known, Suspected, or Potential
Coldwater Fishery- Restored	Sediment - Known	Degraded fish habitat Degraded macroinvertebrate diversity Degraded fish spawning habitat	Streambanks - Known Agriculture - Suspected Road stream crossings - Known Construction areas -Potential
	Nutrients - Suspected	Oxygen depletion Algal/Nuisance aquatic plant growth	Failing septic systems - Suspected Commercial/residential fertilizers- Known Animal waste runoff - Suspected Stormwater runoff- Known
	Temperature - Known	Increased water temperatures Reduction in dissolved oxygen	Lack of streamside canopy - Known Water withdrawals shallowing the stream - Potential Water level control structures - Known Stormwater runoff- Known
	Toxic Substances - Known	Degraded fish habitat Degraded macroinvertebrate habitat Degraded benthic organism populations	Illicit Discharges - Suspected Point sources (superfund / oil wells - Known Stormwater runoff- Known Atmospheric contamination - Known
	Invasive Species - Suspected	Out competing native species Degradation/Loss of habitat	Connected waterways - Potential Accidental introduction - Known
Aquatic Life and Wildlife - Restored	Sediment - Known	Degraded fish habitat Degraded macroinvertebrate diversity Degraded fish spawning habitat	Streambanks - Known Agriculture - Suspected Road stream crossings - Known Construction areas -Potential
	Nutrients - Suspected	Oxygen depletion Algal/Nuisance aquatic plant growth	Failing septic systems - Suspected Commercial/residential fertilizers- Known Animal waste runoff - Suspected Stormwater runoff- Known

Designated Use to be Restored, Improved, or Protected	Pollutants of Concern Known, Suspected, or Potential	Impacts of Pollution on Designated Use	Source of Pollution Known, Suspected, or Potential
Aquatic Life and Wildlife – Restored (ctd)	Temperature - Suspected	Increased water temperatures Reduction in dissolved oxygen	Lack of streamside canopy - Known Water withdrawals shallowing the stream - Potential Water level control structures - Known Stormwater runoff- Known
	Toxic Substances - Known	Degraded fish habitat Degraded macroinvertebrate habitat Degraded benthic organism populations	Illicit discharges - Suspected Point sources (superfund / oil wells - Known Stormwater runoff- Known Atmospheric contamination - Known
	Invasive Species - Suspected	Out competing native species Loss/Loss of habitat	Connected waterways - Potential Accidental introduction - Known
Partial Body Contact Recreation - Restored	Fecal coliform and *E.coli* - Known	Impaired recreational uses Degraded habitat	Failing septic systems - Suspected Pump Station Failures – Potential -has happened Animal waste runoff - Potential
	Nutrients - Suspected	Oxygen depletion Algal/Nuisance aquatic plant growth	Failing septic systems - Suspected Commercial/residential fertilizers- Known Animal waste runoff - Suspected Stormwater runoff- Known
	Toxic Substances - Known	Degraded fish habitat Degraded benthic organism populations Degraded macroinvertebrate habitat	Illicit discharges - Suspected Point sources (superfund / oil wells - Known Stormwater runoff- Known Atmospheric contamination - Known
Total Body Contact Recreation - Restored	Fecal coliform and *E.coli* - Known	Impaired recreational uses Degraded habitat	Failing septic systems - Suspected Pump Station Failures - Potential Animal waste runoff - Potential
	Nutrients - Suspected	Oxygen depletion Algal/Nuisance aquatic plant growth	Failing septic systems - Suspected Commercial/Residential fertilizers- Known Animal waste runoff - Potential Stormwater runoff- Known

Designated Use to be Restored, Improved, or Protected	Pollutants of Concern Known, Suspected, or Potential	Impacts of Pollution on Designated Use	Source of Pollution Known, Suspected, or Potential
Total Body Contact Recreation – Restored (ctd)	Toxic Substances - Known	Degraded fish habitat Degraded macroinvertebrate habitat Degraded benthic organism populations	Illicit discharges - Suspected Point sources (superfund / oil wells – Known Stormwater runoff- Known Atmospheric contamination - Known
Warmwater Fishery - Improved	Sediment - Known	Degraded fish habitat Degraded macroinvertebrate diversity Degraded fish spawning habitat	Streambanks - Known Agriculture - Suspected Road stream crossings - Known Construction areas -Potential
	Nutrients - Suspected	Oxygen depletion Algal/Nuisance aquatic plant growth	Failing septic systems - Suspected Commercial/residential fertilizers- Known Animal waste runoff - Potential Stormwater runoff- Known
	Temperature - Known	Increased water temperatures Reduction in dissolved oxygen	Lack of streamside canopy - Known Water withdrawals shallowing the stream - Potential Water level control structures - Known Stormwater runoff- Known
	Toxic Substances - Known	Degraded fish habitat Degraded benthic organism populations Degraded macroinvertebrate habitat	Illicit discharges - Suspected Point sources (superfund / oil wells - Known Stormwater runoff- Known Atmospheric contamination - Known
	Invasive Species - Suspected	Out competing native species Loss/Loss of habitat	Connected waterways - Potential Accidental introduction - Known
Navigation - Improved	Sediment - Known	Degraded recreational use Degraded lake access	Streambanks - Known Agriculture - Suspected Road Stream Crossings - Known Lack of riparian vegetation - Suspected Construction areas - Potential
	Nutrients - Known	Oxygen depletion Algal/Nuisance aquatic plant growth	Failing septic systems - Suspected Commercial/residential fertilizers- Known Animal waste runoff - Potential Stormwater runoff- Known

Designated Use to be Restored, Improved, or Protected	Pollutants of Concern Known, Suspected, or Potential	Impacts of Pollution on Designated Use	Source of Pollution Known, Suspected, or Potential
Navigation – Improved (ctd)	Invasive Species - Known	Out competing native species Loss/Loss of habitat	Connected waterways - Potential Accidental introduction - Known
Agriculture - Protected	Sediment - Suspected	Decreased availability of water for irrigation/livestock Soil loss on croplands	Wind erosion - Known Stormwater erosion- Known Construction areas - Known Lack of riparian vegetation - Potential
Industrial Water Supply - Protected	Sediment - Suspected	Decreased availability of water	Streambanks - Known Agriculture - Suspected Road Stream Crossings - Known Lack of riparian vegetation - Suspected Construction areas - Potential
	Invasive Species - Potential	Clogging of water intake valves	Connected waterways - Potential Accidental introduction - Known
Public Water Supply - Protected	Sediment - Suspected	Decreased availability of water	Streambanks - Known Agriculture - Suspected Road Stream Crossings - Known Lack of riparian vegetation - Suspected Construction areas - Potential
	Invasive Species - Suspected	Clogging of water intake valves	Connected waterways - Potential Accidental introduction - Known
	Toxic Substances - Known	Degraded fish habitat Degraded benthic organism populations Degraded macroinvertebrate habitat	Illicit discharges - Suspected Point sources (superfund / oil wells - Known Stormwater runoff- Known Atmospheric contamination - Known
	Fecal coliform and *E.coli* - Known	Impaired recreational uses Degraded habitat	Failing septic systems - Suspected Pump Station Failures - Potential Animal waste runoff - Potential

Chapter 4 Critical Areas In The Bear Creek & Bear Lake Watershed

4.1 Determination of Critical Areas

The Bear Creek & Bear Lake Watershed has four designated uses that are impaired and two designated uses that are threatened. The impaired designated uses that should be restored throughout the watershed include coldwater fishery, aquatic life and wildlife, partial body contact recreation, and total body contact recreation. The threatened designated uses to be restored include warm water fishery and navigation. The following sections will identify specific areas in the watershed that currently and potentially have a negative affect on water quality and are most sensitive to changes in land use.
The determination of critical areas plays an important part in developing the Watershed Management Plan. Critical areas are those areas with the greatest potential to deliver sediments, nutrients, or other pollutants to surface water and groundwater. Critical areas within the Bear Creek & Bear Lake Watershed are defined using five categories. Moderate risk and high-risk categories are areas of highest priority and are most apt to contribute pollution to the Bear Creek & Bear Lake Watershed (see Figure 19). The categories include:

1) **No known risk**: Non-agricultural areas greater than ¼ mile from a river/stream/drain/lake.

2) **Very low risk**: Non-agricultural areas less than ¼ mile from a river/stream/lake/drain.

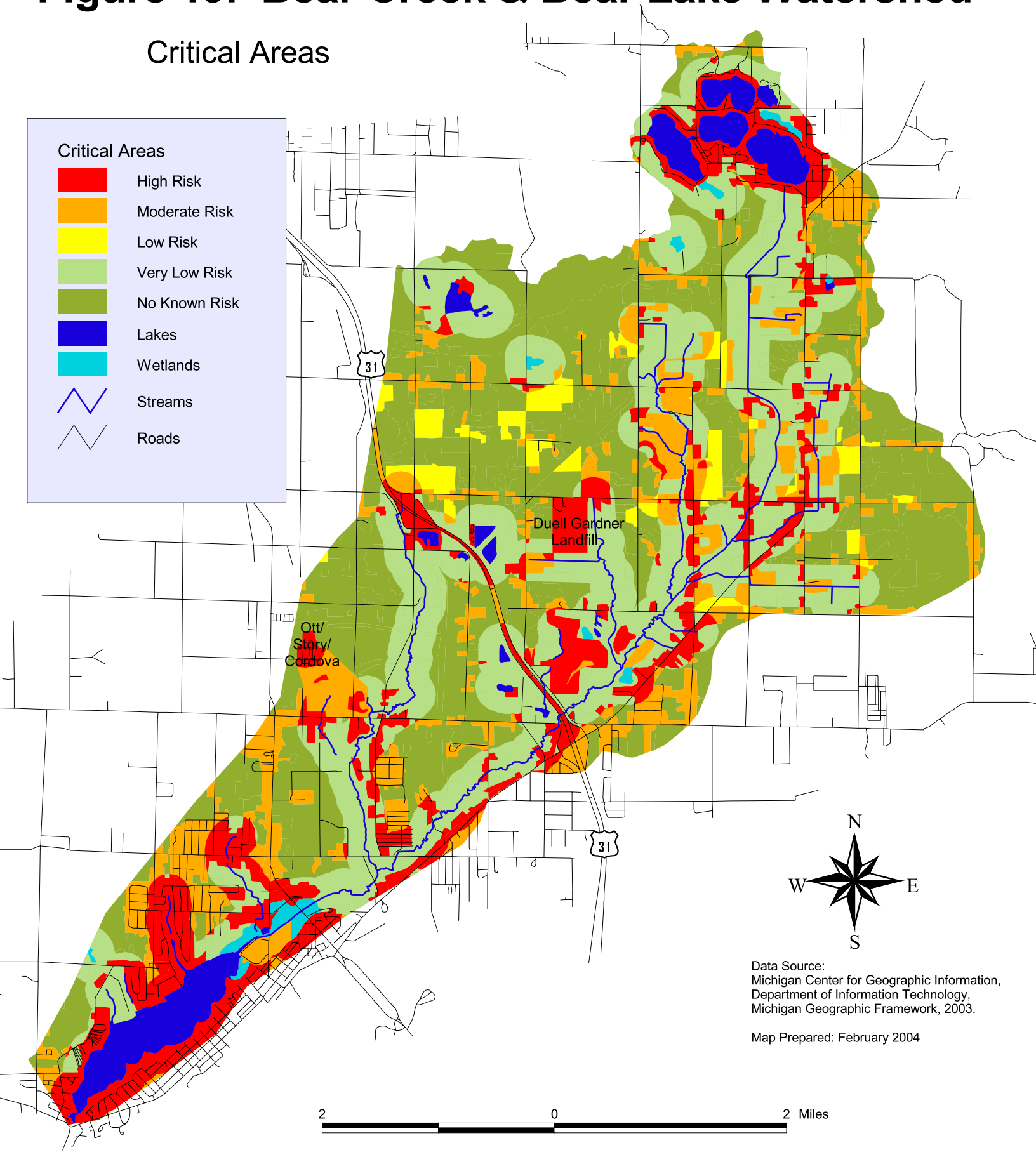
3) **Low risk**: Agricultural areas greater than ¼ mile from a river/stream/drain/lake.

4) **Moderate risk**: a) Urban and barren areas greater than ¼ mile from a river/steam/lake/drain. b) Agricultural areas less than ¼ mile from a river/stream/drain/lake.

5) **High risk**: a) Urban and barren areas less than ¼ mile from a river/stream/drain/lake. b) Superfund sites, and their immediate drainage area.

~ *Urban Areas* – residential, commercial, industrial, and other developed land (i.e. roadways, parking lots, etc.).
~ *Agricultural Areas* – Christmas tree plantations, orchards, blueberry fields, tilled crops, and permanent pasture lands.
~ *Non-Agricultural Areas* – woodlands, open fields, or other undeveloped open space.

Figure 19. Bear Creek & Bear Lake Watershed



No Known Risk

The *no known risk* category is defined as non-agricultural areas greater than ¼ mile from Bear Creek, Bear Lake, or any of their tributaries. Non-agricultural land is defined as woodlands, open fields, or other undeveloped open space. These particular land uses do not have a direct connection to Bear Creek, Bear Lake, or any of their tributaries; which is why they are categorized as *no known risk* areas. Woodlands and open fields have a low potential for runoff because they are typically covered with vegetation. Therefore there is little to no risk that these areas will contribute sediment to adjacent waterways. Also, any pollutants or excess nutrients will have a low possibility of reaching the waterway greater than ¼ mile away and because of the very low rate of stormwater runoff for these land uses.

Very low risk:

The *very low risk* category is defined as non-agricultural areas, such as woodlands open fields, and other open spaces less than a ¼ mile from Bear Creek, Bear Lake, or any of their tributaries. Mature woodlands with dense canopy surrounding Bear Creek, Bear Lake, or their tributaries do not allow vegetation to grow in the understory thereby exposing more soil to wind and water erosion. These vegetated buffers along streams and lakes filter out soil, contaminants, and excess nutrients before they can enter the water but the lack of understory vegetation increases the potential for erosion along the stream. In addition, many of the open fields in the upper portion of the watershed are drained to lower the water table. Vegetation is prevented from establishing along these maintained drains which then contributes to the problem of thermal pollution. Without vegetation to screen the sun from the stream, water temperatures rise, negatively impacting the coldwater fishery. Although there are some negative impacts associated with open spaces, most are naturally occurring and pose a very low risk to the watershed.

Low Risk

The *low risk* category is defined as agricultural areas greater than ¼ mile from Bear Creek, Bear Lake, or any of their tributaries. Agricultural areas include Christmas tree plantations, orchards, blueberry fields, tilled crops, and pasture land. Agricultural land greater than ¼ mile from Bear Creek, Bear Lake, or any of their tributaries do not have a direct connection to these waterways. However, typical agriculture management may bring along a small amount of risk. For example, many agricultural areas require multiple applications of fertilizer/pesticide products along with irrigation to produce a high yield/high quality crop. High amounts of irrigation increases leaching and runoff potential into groundwater and surrounding areas. As the distance between agricultural areas and waterways in the watershed increases, the likelihood of negative impacts to the water quality decreases.

Moderate Risk

Urban areas including, residential, commercial, industrial, and all other developed land, greater than ¼ mile from Bear Creek, Bear Lake, or any of their tributaries, are considered to be *moderate risk* areas. Urban areas outside the ¼ mile proximity from Bear Creek, Bear Lake, and all of their tributaries pose a potential risk to the system because of stormwater drains. Excess nutrients from lawns (fertilizers/pesticides), oil,

gas, household hazardous wastes, etc. flow directly into Bear Creek or Bear Lake, they collect in the stormdrains which drain directly into the stream or lake without being treated. A number of concerns are raised with this issue including contamination of water with household chemicals, excess nutrients causing nuisance algal blooms, and excess sediment covering valuable fish spawning habitats.

Barren areas include open sand dunes, blowout areas, and areas with no vegetative cover. Barren areas greater than ¼ mile from a river/steam/lake/drain are considered to be *moderate risk* because of their moderate potential to contribute sediments to the system. Although not directly adjacent to the stream, wind and storm events can transport sediment to waterways in the watershed. Excessive sedimentation is a high concern for the Bear Creek Watershed. These barren areas are likely to be a source of sediment to the system.

Agricultural lands such as Christmas tree plantations, orchards, asparagus fields, blueberry fields, tilled crops, and permanent pasture lands that are close (within ¼ mile) of Bear Creek, Bear Lake, and any of their tributaries are also considered *moderate risk*. Agricultural practices can potentially contribute a large amount of fertilizer and/or pesticide to the system, which will have negative ecological effects. Agricultural runoff from irrigation or storm events carries nutrients and sediment into the stream or lake, eventually covering spawning habitats. Portions of the upper watershed consist of drains that are frequently maintained to deter vegetation from establishing. Therefore little canopy is allowed to establish which then exposes the water to the sun. This lack of canopy increases the water temperature, which negatively impacts the coldwater fishery. Unrestricted livestock access may also be contributing nutrients to Bear Creek, Bear Lake, and its tributaries. The use of the stream by agricultural livestock may also erode the banks of the stream, contributing to further sedimentation.

High Risk

The *high risk* category is defined as urban and barren areas less than ¼ mile from waterways, and the immediate drainage areas of the Federally designated Superfund sites. Urban areas, such as residential, commercial, industrial, and all other developed areas close to waterways have a high potential for negatively impacting the water quality; therefore have been classified as *high risk*. Urban areas that are directly linked to Bear Creek, Bear Lake, its tributaries, and wetlands via storm drains, storm sewers, and surface runoff, negatively impact the watershed in several ways. Stormwater carries with it fertilizers, pesticides, oil, gas, and household hazardous wastes. These are some of the types of pollutants that eventually end up in Bear Creek and/or Bear Lake. Another reason urban areas close to the water are considered high risk is the lack of vegetation around the stream and lake. A typical residential lot on Bear Lake consists of a heavily maintained (fertilizers, mowing etc,) and manicured lawn with little or no buffer strip. Vegetative shoreline and streamside buffers act as filters trapping soil, contaminants, and excess nutrients before they enter the lake or stream. In addition, the lack of these buffers provides little to no ecological value for fish and wildlife and can contribute to thermal pollution of the water body.

Barren areas include open sand dunes, blowout areas, and areas with no vegetative cover. Barren areas less than ¼ mile from a river/steam/lake/drain are considered to be *high risk* because of their high potential to contribute sediments to the system. Erosive factors likely transport sediment to waterways in the watershed from these barren areas. Excessive sedimentation is of high concern in the Bear Creek Watershed. These barren areas are likely to be a contributing source of sediment to the streams and therefore are designated as *high risk* areas.

Although this Bear Creek and Bear Lake Watershed Management Plan does not cover point sources of pollution, for the sake of creating a comprehensive management plan, and because of the known historical impacts of the Federally designated Superfund Sites, they have been included in the critical area designations. The *high risk* designation refers to the historically contaminated portions of the superfund sites only. In addition, a *high risk* designation implies that there is a potential for further impact from these sources and that continued monitoring and inventorying is necessary to prevent further degradation from these point sources. These sites are unique in the problems they pose for the watershed and the activities needed to remediate their impacts. However, for the interest of compiling a complete perspective of the critical areas of the watershed, and to increase the public awareness of their presence, the immediate areas of the Superfund sites are classified as *high risk*.

There are two superfund sites in the watershed, the Duell Gardner landfill, and the Ott/Story/Cordova site. The Bear Lake and Bear Creek Watershed Advisory Committee decided that it is important to consider impacts in adjacent areas to these sensitive areas. Adjacent land uses may potentially expose contaminated soils, or release contaminated groundwater. For example, increased stormwater discharge from developments adjacent to these sites may increase both the volume and velocity of the receiving waterway, thereby increasing the frequency of channel forming storm events which could potentially expose contaminated sediments or toxic substances. Therefore if development occurs adjacent to these areas, special stringent regulations need to be in place to prevent adverse effects to the watershed. Continual monitoring and additional research needs to be conducted to ensure complete exclusion of contamination risk resulting from possible development. Because of this potential additional risk of further contamination in the watershed, those portions of land within the superfund sites that were historically contaminated are considered to be *high risk,* whereas areas not contaminated but still within the superfund sites are designated using the standard critical area designation criteria. However, land area southeast of the Ott/Story/Cordova site is classified as *moderate risk*, because of the extent of the traveling contaminated groundwater. Areas north and northwest of the immediate *high risk* area, poses *no known risk* in its current state (Figure 19). Current treatments have improved the conditions of both superfund sites and there is no doubt that if current clean-up efforts were abandoned, the watershed would reap definite negative impacts.

4.2 Designated Uses

As stated earlier in Chapter 3, there are nine State Designated Uses that are defined for all of Michigan's water bodies. All surface waters are designated for and shall be protected for all nine of the following uses: Agriculture, Industrial water supply, Public water supply at the point of intake, navigation, Warm-water or Coldwater fishery, Other indigenous aquatic life and wildlife, Partial body contact recreation, and Total body contact recreation between May 1st and October 31st. The following table demonstrates the State Designated Uses and lists whether they are currently being met in the Bear Creek and Bear Lake Watershed.

Table 12. Designated Uses and Their Attainment Status In The Bear Creek & Bear Lake Watershed

Designated Uses	Non-attainment (Impaired) or Threatened status
Cold-water fishery	Non-attainment/Impaired
Aquatic life and wildlife	Non-attainment/Impaired
Partial body contact recreation	Non-attainment/Impaired
Total body contact recreation	Non-attainment/Impaired
Warm-water fishery	Threatened (*to be protected*)
Navigation	Threatened (*to be protected*)
Agriculture	Attainment
Industrial water supply	Attainment
Public water supply	Attainment

It is important to consider the State Designated Uses in defining critical areas in that critical areas are the areas where the majority of the pollutants are being contributed which have the potential to significantly impact the watershed. These sources need to be addressed to restore the impaired designated uses.

4.3 Inventory of Critical Areas

The list of pollutants impairing or threatening each designated use was ranked in an effort determine which pollutants were causing the majority of the designated use impairment. Each pollutant is prioritized based on the number for designated uses that the pollutant threatens or impairs.

Table 13. Pollutants and Their Associated Impact Priority Rank to Impaired and Threatened State Designated Uses

Designated Use	Pollutants Known (k), Suspected (s), or Potential (p)	Priority Ranking
Coldwater Fishery - Impaired	Sediment - (k)	1
	Temperature - (k)	2
	Toxic Substances - (k)	3
	Invasive Species - (s)	4
	Nutrients - (s)	5
Aquatic Life and Wildlife-Impaired	Sediment - (k)	1
	Nutrients - (s)	2
	Invasive Species - (s)	3
	Toxic Substances - (k)	4
	Temperature - (s)	5
Partial Body Contact Recreation - Impaired	Fecal coliform and *E.coli - (k)*	1
	Nutrients - (s)	2
	Toxic Substances (k)	3
Total Body Contact Recreation - Impaired	Fecal coliform and *E.coli - (k)*	1
	Nutrients - (s)	2
	Toxic Substances - (k)	3
Warmwater Fishery - Threatened	Sediment - (k)	1
	Nutrients - (s)	2
	Toxic Substances - (k)	3
	Temperature - (k)	4
	Invasive Species - (s)	5
Navigation - Threatened	Nutrients - (k)	1
	Invasive Species - (k)	2
	Sediment - (k)	3

Based upon the pollutants that are impacting each State Designated Use, the Technical Team decided upon the overall ranking of pollutants for the Bear Creek and Bear Lake Watershed. Sediment was chosen as the highest priority due to the broad negative impacts associated with increased sedimentation, and the fact that nutrients as well as many toxic substances are attached to sediment. So by reducing sedimentation to the system, toxic substances and nutrients would be reduced. The following table describes each of the known pollutants and the associated number of designated uses they impact, as well as the priority ranking.

Table 14. The Known Pollutants Impacting the State Designated Uses and Their Associated Overall Priority Ranking

Pollutant	Number of Designated Uses Impacting	Priority Rank
Sediment	4	1
Toxic Substances	5	2
Nutrients	1	3
Invasive Species	1	4
Temperature	2	5
Fecal coliform and *E.coli*	2	6

The known sources to the six pollutants that impair the State Designated uses are listed in the following table. Prioritized sources will help to efficiently guide decision makers and resource managers. Prioritization allows restoration actions to have the largest impact possible by addressing those sources of highest concern.

Table 15. Sources To the Known Pollutants to the State Designated Uses Impacting the Bear Creek and Bear Lake Watershed.

Pollutant	Ranking	Sources	Ranking
Sediment	1	Streambanks	1
		Road Stream Crossings	2
Toxic Substances	2	Atmospheric contamination	1
		Stormwater runoff	2
		Point sources (Superfund Sites, Abandoned Oil Wells)	3
Nutrients	3	Commercial/residential fertilizers	1
		Stormwater runoff	2
		Animal waste runoff	3
		Agriculture	4
Invasive Species	4	Accidental introduction	1
		Connected waterways	2
Temperature	5	Lack of streamside canopy	1
		Stormwater runoff	2
		Water level control structures	3
Fecal coliform and *E.coli*	6	Failing septic systems	1
		Pump Station Failure	2
		Animal waste runoff	3

In addition to ranking the pollutants and their sources, the causes for each source was identified and ranked. Ranking causes to the sources will allow resource managers to better identify locations and areas to implement restoration activities. The following table identifies the causes to the known pollutants for the Bear Creek and Bear Lake Watershed.

Table 16. Causes To the Known & Suspected Sources of Pollutants Impacting the Impaired State Designated Uses in the Bear Creek and Bear Lake Watershed.

Sources	Cause	Ranking
Streambank erosion	Lack of riparian vegetation, Increased volume and velocity	1
Commercial/residential/agricultural fertilizers	Improper application	2
Stormwater runoff	Lack of infiltration, buffer strips	3
Lack of streamside canopy	Maintained lawns and drains	4
Road stream crossing erosion	Increased hydrologic flow	5
Point sources (Superfund Sites, Abandoned Oil Wells)	Improper design	6
Atmospheric contamination	Coal fired power plants	7
Water level control structures	Recreational, aesthetic purposes	8
Failing septic systems	Improper design / Poorly maintained	9
Pump Station Failure	Power outage, outfall design	10
Animal waste runoff	Unrestricted access	11
Accidental introduction of exotics	Lack of awareness	12

4.4 Water Quality Threats to Designated Uses

The pollutants that have the most potential to negatively impact the designated uses and degrade water quality in the Bear Creek and Bear Lake Watershed are, as pointed out earlier, sediment, thermal pollution, excess nutrients, and toxic substances. The critical area analysis done in this chapter identified areas that are highly susceptible to further impact from these pollutants and their sources. However, further inventorying and monitoring is necessary to further identify specific problems in the watershed. Once further inventorying of the critical areas not surveyed is completed, site-specific Best Management Practices (BMPs) may be implemented to reduce the overall pollutant load to the system, therefore encouraging the effort to restore and improve the impaired and threatened designated uses.

Streambank erosion site occurring along the main branch of Bear Creek.

Maintained upper stretch of Bear Creek – contributing sediment, thermal pollution and degrading fish and wildlife habitat

Culvert near capacity, with scoured banks contributing sediment to the stream.

Horse with unrestricted access to Bear Creek

4.5 High Quality Areas in the Bear Creek Watershed

The diverse flora and fauna found in the Bear Creek and Bear Lake provide excellent opportunities to enjoy nature and to observe its interconnected parts. The purpose of pointing out specific high quality areas in the watershed is to draw needed attention to areas where conservation zoning, land preservation, and conservation practices will be most effective in preserving the ecological integrity of the watershed. High quality areas are those most sensitive to development and other disturbances. Implementing the Green Infrastructure Plan, defined by Conservation Design Forum Inc., will provide benefits to the watershed community's desired uses (see Appendix C).

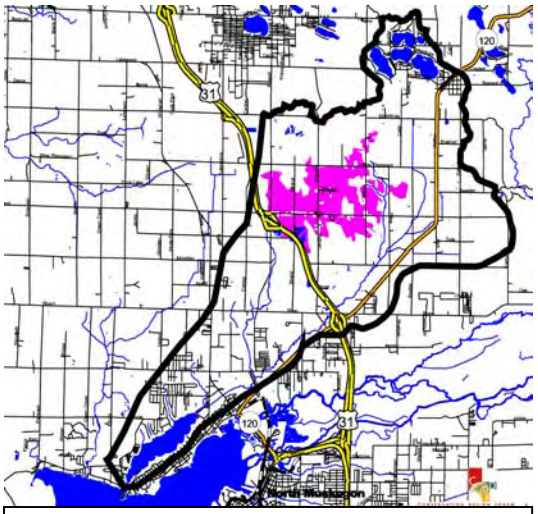


Figure 20. Highly sensitive areas in the Bear Creek and Bear Lake Watershed – Based upon soil characteristics - Source CDF

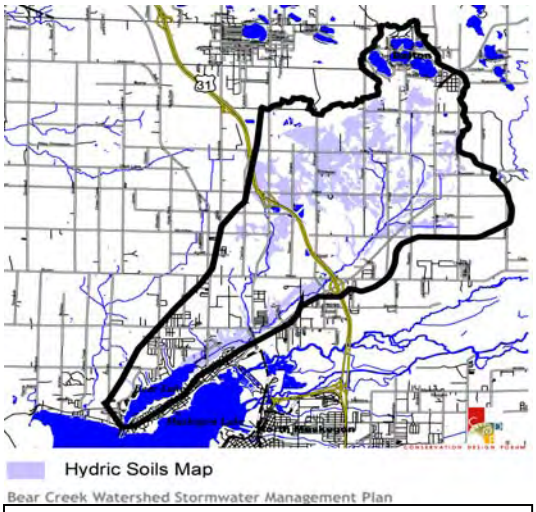
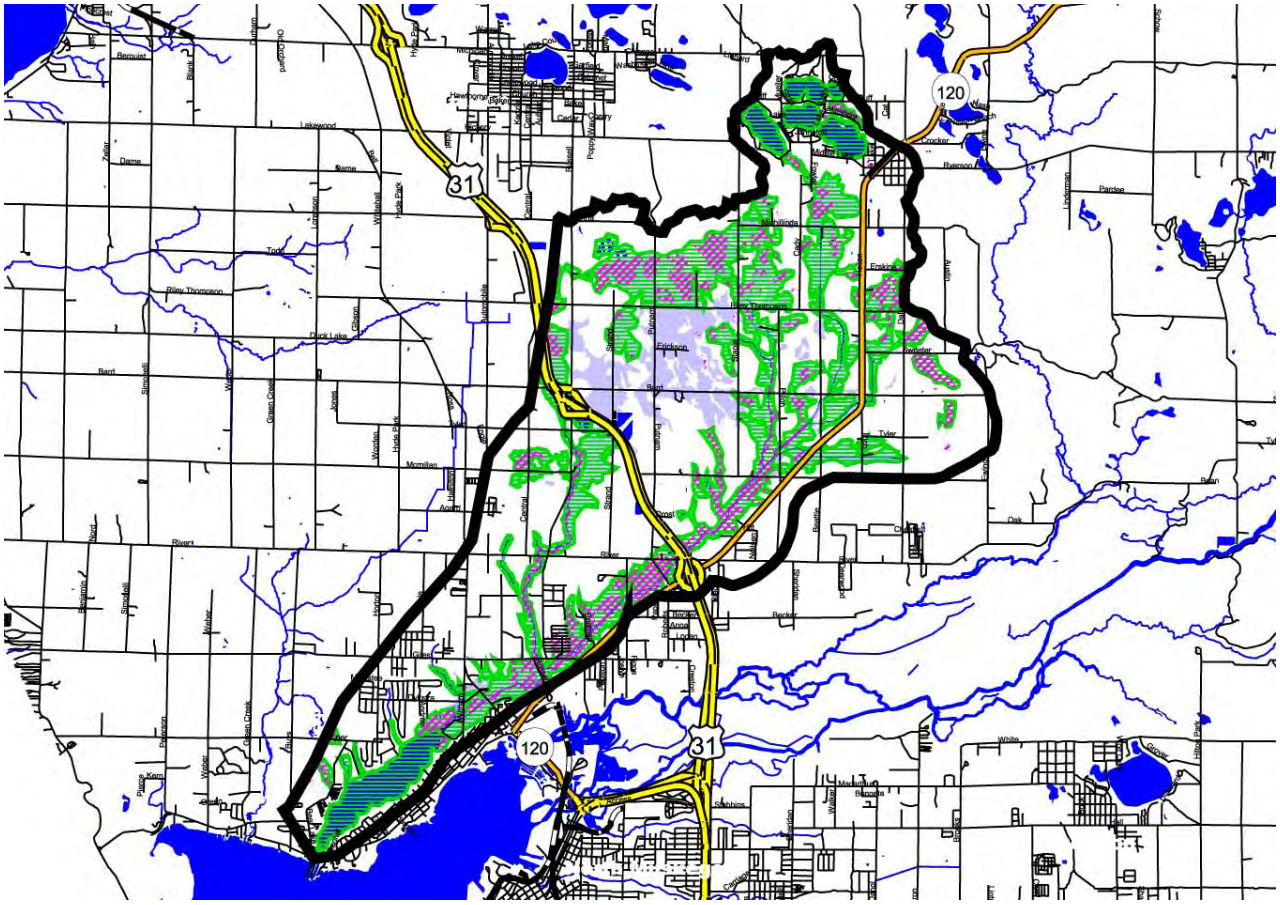


Figure 21. Hydric Soils in the Bear Creek and Bear Lake Watershed - Source CDF

Figure 22. Green Infrastructure Plan for the Bear Creek and Bear Lake Watershed – produced by Conservation Design Forum, 2004



These highly sensitive lands support a wide array of plant and animal species, several of which are of special concern, threatened, or endangered. A table listing all of the known occurrences of threatened, endangered, and special concern species within the Bear Creek and Bear Lake watershed is listed in Chapter 2.8. The species and community information is derived from the Michigan Natural Features Inventory (MNFI) database. It should be noted that additional research and continual monitoring of these unique species is necessary to ensure that the complex web of interdependent organisms is preserved.

The implementation of the Green Infrastructure Plan (CDF, 2004) will protect the watershed against direct modification of the unique stream and wetland resources. The Green Infrastructure Plan identifies areas and natural resources that are most sensitive to development and other disturbances. When implemented it will preserve the natural hydrology of the watershed, reduce streambank erosion potential, improve water quality, protect against flooding, preserve and enhance wildlife habitat connectivity, and would drastically increase the potential for outdoor recreation (CDF, 2004). It is hoped that the Green Infrastructure Plan be integrated into municipal and county land use plans and open space zoning. For more information about the Green Infrastructure Plan see Appendix C.

Chapter 5 Water Quality Goals In The Bear Creek & Bear Lake Watershed

5.1 Goals of the Bear Creek & Bear Lake Watershed

The goal of the Bear Creek & Bear Lake Watershed Project is to restore, improve, and protect the Bear Creek & Bear Lake Watershed designated uses by reducing the amount of nonpoint source pollution impacting water quality in Bear Creek, Bear Lake, and their tributaries through information and education, watershed monitoring, and the installation of Best Management Practices.

The cold water fishery, aquatic life and wildlife, and both partial and total body contact designated uses are impaired in the watershed and the warmwater fishery, and navigation designated uses are currently threatened. The overarching goal of the Bear Creek & Bear Lake Watershed Project is to reduce the negative impact that pollutants such as excessive nutrients, thermal pollution, toxic substances, and sedimentation have on both the impaired and/or threatened designated uses.

The Bear Creek & Bear Lake Watershed Advisory Committee (BCWAC) formed in an effort to address community and environmental concerns in the watershed. The BCWAC will act as an effective long-term steward of the Bear Lake and Bear Creek Watershed. The overall goal of the BCWAC is "…*To restore, conserve, and protect the Bear Creek and Bear Lake Watershed as a valuable natural resource and to inspire community stewardship through awareness, education, and research*". One of BCWAC's main roles is to inform and educate specific communities within the. Information and Education activities/strategies include workshops, informational meetings, watershed tours, literature etc., refer to Appendix A for greater explanation of information and education techniques.

Water quality monitoring is a critical aspect of the Bear Creek and Bear Lake Watershed Management Project. Through the volunteer water quality monitoring program at the Muskegon Conservation District, the Adopt-A-Watershed program, and both continued and increased sampling by area schools and the BLWAC, valuable information will be compiled regarding Bear Creek, Bear Lake and their tributaries. In addition, Grand Valley State University's Muskegon Lake Water Quality Monitoring Project began recently and will provide valuable information as to the water quality conditions from sampling points near the outlet of Bear Lake into Muskegon Lake. This data, combined with the MDEQ lakes and streams sampling schedule will monitor the success/failure of installed BMP's and provide a guide for future stewardship efforts.

Critical areas within the watershed were identified in Chapter 4 as the areas needing the most improvement and attention. Critical areas are those areas with the greatest potential to deliver sediments, nutrients, or other pollutants to surface water and groundwater. In an effort to reduce the amount of sediment leaving fields, reduce the amount of nutrients entering the water courses, understand the overall flow dynamics of the river and its tributaries, and improve the water quality of the Bear Creek system, Resource Management System plans (RMS) will be developed for site-specific areas in the watershed. Resource Management Plans will be used to: identify the pollutants and their sources to be addressed, identify the resource management system that is to be installed, schedule the installation and maintenance of BMPs, and allocate cost-share and rental payments.

5.2 Pollutant Reduction Goals

The overarching goal of the Bear Creek and Bear Lake Watershed project is to improve and/or maintain the integrity of the watershed by reducing the amount of total pollutants to the level that they no longer degrade the state designated uses. Several NPS pollutants that threaten the water quality of the Bear Creek & Bear Lake Watershed are: sedimentation, toxic substances, excessive nutrients, non-native invasive species, and thermal pollution. Reducing these pollutants will help to restore the coldwater fishery, aquatic life and wildlife, and the partial and total body contact designated uses and will prevent further degradation.

Specific reduction goals – *Bear Creek and Bear Lake Watershed*
5.2-1 Excessive Nutrients:
The Bear Creek & Bear Lake Watershed was monitored in the summer of 2001. It was included in the Muskegon River 303(d) cycle, as a subwatershed of the Muskegon River. Monitoring was done on Bear Lake but was limited on Bear Creek and its tributaries. Bear Lake is on the 303(d) list for non-attainment due to fish consumption advisories (FCAs), excessive polychlorinated biphenyls (PCBs), mercury, nutrient enrichment, and nuisance algal growths (MDEQ 2002). The main sources of nutrients are from non-point sources. The largest challenge in reducing over nutrification is with home and agricultural fertilizer uses, animal wastes, and failing septic systems.

In addition to curbing the excessive and rapid aquatic plant growth, control of nutrient loading will increase the dissolved oxygen levels at lower depths within the water column which will improve suitable fish and other aquatic life habitat in Bear Lake.

It should be noted that there is very little data on the nutrient concentrations of Bear Lake. Additional sampling needs to be conducted to gain a more comprehensive understanding of the trophic condition and status of Bear Lake and Bear Creek. Existing data is limited and any further compiling will aid in the effort to effectively monitor nutrient inputs to Bear Lake and therefore outputs to Muskegon Lake Area of Concern (AOC).

Table 17. Volunteer Water Quality Monitoring Data Collected Along the Shoreline of Bear Lake

Sample Date	10/10/03	10/10/03	10/13/03	10/13/03	10/15/03	10/15/03	10/15/03	Average
Phosphorus	X	X	0.09mg/L	0.21mg/L	0.0mg/L	0.03mg/L	0.05mg/L	0.076mg/L
Temperature	X	13 C	15 C	18 C	10 C	10 C	14 C	13.33 C
DO	X	6mg/L 55%	11mg/L 108%	13mg/L 135%	6mg/L 55%	7.5mg/L 68%	6mg/L 60%	8.25gm/L 79%
BOD	X	0mg/L	5mg/L	2mg/L	1mg/L	X	6mg/L	3mg/L
pH	7.9	8.5	5.5	5.8	7.4	7.3	6	6.9
Nitrates	X	X	1.32mg/L	0.44mg/L	0.2mg/L	0.888mg/L	0.88mg/L	0.7mg/L
Turbidity	X	17NTU	12NTU	12NTU	13.5NTU	13NTU	16NTU	14NTU
Total Solids	X	120mg/L	180mg/L	190mg/L	10mg/L	210mg/L	1000mg/L	175mg/L
F. Coli	X	144col/100 mL	X	23col/100m L	16col/100m L	640col/100 mL	4col/100mL	165col/100 mL
E. Coli	X	0 col/100mL	100 col/100mL	X	0 col/100mL	100 col/100mL	100 col/100mL	60 col/100mL

Targeted Restoration Condition:

- As of 2002 Bear Lake was listed as impaired for nutrient enrichment and nuisance algal growth. Although specific concentration data is yet to be gathered for both Bear Creek and Bear Lake, a general reduction goal would be to have the watershed de-listed by 2016. Allows 2 years for initial implementation to reduce severe sources, and 10 years to reduce all other anthropogenic caused nutrient sources.

- Significantly reduce all anthropogenic (human caused) nutrient contamination sources within the land area of the Bear Creek and Bear Lake Watershed by 15% after initial implementation period completion in 2006, and an additional 35% (50% total reduction) by 2011 *Restoration target attainment is dependent upon initial comprehensive data collection being compiled.

- Adoption and community wide support for a ban on phosphorous containing residential fertilizers, and enforcement by local units of government to ensure its effectiveness by 2011. Allows 2 years for I & E Strategy implementation, and 5 years to gain and encourage community support.

Research Needs:

- Conduct a comprehensive nutrient study of the Bear Lake and Bear Creek. Determine the trophic status of the lake, major nutrient inputs to the system, and locate anthropogenic sources that may be negatively impacting the system (septic, residential, farms, stormwater runoff, or others) by 2006.
- Evaluate non-point source nutrient loadings and contaminants to ascertain seasonal loadings.
- Evaluate organic loading to the system. Continue to monitor nitrogen and phosphorous during seasonal turnovers. Monitor dissolved oxygen and biochemical oxygen demand throughout the year. Sampling should take place semi-annually until reduction goals are met, and then every 4-5 yrs. thereafter.

- Measure community support for a regional ban on phosphorous containing fertilizers.

5.2-2 Thermal Pollution:

Thermal pollution is the warming of the water temperature to a degree that limits the amount of dissolved oxygen available for use by aquatic life. The primary impact on stream temperatures results from the removal or reduction of streamside or shoreline vegetation that exposes the water surface to direct solar radiation by day and the open sky at night, and increased stormwater/urban runoff (Satterlund & Adams, 1992). The installation of vegetated shoreline and streamside buffers would help by increasing canopy cover and providing streambank stabilization. In addition, buffers act as a filter trapping excess nutrients and other pollutants before they enter the water.

The majority of the agricultural drains in the upper watershed are frequently maintained to deter vegetation from establishing and therefore act as vectors of thermal pollution to the mostly groundwater fed river system. In addition, stormwater outfalls in the more developed lower end of the watershed and along the M-120 corridor, are a major contributor to the problem of thermal pollution. When rain falls onto hot rooftops, parking lots, or streets it quickly warms as it is directed toward storm-sewers, which directly output into Bear Creek or its tributaries. The result is an increase in water temperature and decreased in stream habitat suitability for the coldwater fishery. There are many management practices that should be implemented to slow the release of stormwater to improve water quality and restore the coldwater fishery designated use (see Appendix C, Stormwater Management Plan).

Targeted Restoration Condition:

- Work with Muskegon County Drain Commission, local units of government, and the NPDES Phase II Stormwater Committee to implement Best Management Practices (BMPs) that will significantly reduce thermal pollution to designated County drains.

- Work with Muskegon County government to establish a countywide stormwater ordinance to better deal with current and upcoming stormwater management issues by 2006. Allow for 2 years of Information and Education Strategy Implementation, to gain community and political support.

- The overall restoration condition for thermal pollution is to improve and restore the entire length of Bear Creek and its immediate tributaries to a designated coldwater stream. Little Bear Creek should be preserved and protected as a state designated coldwater fishery. Improve and restore the middle portion of Bear Creek (from the L. Bear Creek confluence to McMillan Rd.) to a condition capable of supporting a coldwater fishery, and to ensure that areas with coldwater characteristics become designated as such by the MDNR.

- Maintain stream temperatures to such a degree that will be suitable habitat for a cold water fishery by re-vegetating stream canopy along the drainage ditches in the upper portion of the watershed. Work with the Muskegon County Drain Commission to

implement BMP practices that will allow for canopy growth along drainage ditches. Comprehensive monitoring of stormwater inputs and urban runoff to ensure further degradation and habitat impairment in avoided.

Research Needs:

- Comprehensive temperature monitoring of both Bear Creek and Bear Lake to determine major thermal pollution inputs and locate anthropogenic sources that are negatively impacting the system
- Gather further input from watershed residents to design methods and programs for their support of efforts to restore and improve Bear Creek to a coldwater stream.

5.2-3 Toxic Substances:

Many different toxic substances may contaminate water bodies through sources such as municipal and industrial discharges, unlined landfills, and runoff from urban or agricultural land. In addition, there is widespread atmospheric mercury deposition into most of Michigan's surface waters. Mercury is of high concern because it bio-accumulates and is shown to be hazardous to wildlife and human health. As a result of the bioaccumulation in fish, there is a statewide mercury-based fish consumption advisory (FCA) that is applied to all of Michigan's inland lakes (MDNR 2002).

In addition to the atmospheric input of toxic substances, stormwater and urban runoff (containing oils, grease, and solids) are an ever increasing concern and are major contributors of toxic substances in the watershed. Impervious surfaces in urbanized areas of the watershed contribute to toxic substances during storm events when water runs off streets, parking lots, and roofs which enters storm drains leading to Bear Creek, Lake, and any of their tributaries.

Targeted Restoration Condition:

- No consumption warnings on fish in Bear Lake due to watershed sources. Chemical concentrations in tissues must be equal or below levels found in other areas of the Great Lakes not listed as Areas Of Concern by 2011. Allows for 2 years installation of recommended stormwater BMPs, and 5 years for additional BMP site identification to further enhance stormwater treatment.

- Caged fish experiments at Bear Lake outlet to Muskegon Lake and in selected locals in Bear Creek, as performed by MDNR, meet state consumption standards. Must meet these standards for 2 successive years.

- Work with Muskegon County government to establish a countywide stormwater ordinance to better deal with current and upcoming stormwater management issues by 2006. Allow for 2 years of Information and Education Strategy Implementation to gain community and political support.

- Bear Lake water quality tests meet all state MDEQ standards for full and partial body contact during 4 successive years starting in 2006. After 2 years of implementation

activities, water quality improvements will be realized. In addition, water quality tests will act as a monitoring tool.

- Documentation of population increases of pollution intolerant benthic organisms (including Hexagenia mayfly) for 3 consecutive years in, L. Bear Creek, and the unnamed tributary to L. Bear Creek, starting in 2006. Allows 2 years of implementation activities and water quality improvements to occur.

Research Needs:

- Determine the level of toxic contaminants for individual fish species within Bear Lake and provide localized consumption advisories if needed. Focus sampling on species of greatest importance to Bear Lake/Bear Creek system
- Regular benthic macroinvertebrate surveys in both Bear Lake and Little Bear Cr. and Bear Creek, and research to determine overall impact to the aquatic food web.
- Stormwater outfall sampling along Bear Creek and Bear Lake measuring toxicity, temperature, and solids.

5.2-4 Sedimentation:

Excessive sedimentation and erosion creates non-point source pollution. Sources of sediment in the Bear Creek / Lake Watershed include streambank erosion, erosion from road/stream crossing sites, construction sites, and agricultural cropland. Though erosion is a naturally occurring process, the effects of accelerated erosion and sedimentation can have devastating impacts on aquatic ecosystems by degrading habitat and decreasing biodiversity. The success of coldwater fish in Bear Creek has been limited as a result of this lack of habitat.

Targeted Restoration Condition:

- No erosion from human activities within the watershed (streambank erosion sites, road/stream crossings). Natural erosion and sedimentation processes continue.

- Implement hydrologically sound stormwater management activities so as to maintain the historic variability of channel forming storm events in the watershed.

Streambank erosion

- Utilize the Streambank Erosion Inventory (Appendix B) to eliminate the "severe" sites along Bear Creek and its tributaries. Restore all severe sites by 2006, which will reduce the total amount of sediment entering the system by 82.5 tons/year (see Table 18 below).

- Utilize the Streambank Erosion Inventory to restore both the "moderate" and "severe" sites along Bear Creek and its tributaries by 2011. This will reduce the total sediment load by 262.7 tons/year. Allows for an initial 2 year implementation period to restore severe sites, and an additional 5 years to address remaining moderate and additionally identified severe sites.

Table 18. Streambank Erosion Sites and Their Sediment Inputs to the Bear Creek Watershed and Associated Restoration Calculations (See Figure 17, Streambank Erosion Sites)

Location/Map Name	Severity Index	Length (ft)	Height (ft)	Depth (ft)	Lateral Recession Rate	Dry Density Soil Wt	Total Loss/Yr (tons)
2	30	60	3.5	1	0.13	0.055	1.50
3*	26	40	4	1	0.03	0.055	0.26
	36	50	6	1	0.13	0.055	2.15
4	35	60	3	1	0.13	0.055	1.29
5	33	150	50	1	0.13	0.055	53.63
6*	31	30	4	1	0.13	0.055	0.86
	30	50	9	1	0.13	0.055	3.22
7	26	30	3	1	0.03	0.055	0.15
8	21	7	5	1	0.03	0.055	0.06
9	29	100	6	1	0.03	0.055	0.99
10	27	120	4	1	0.03	0.055	0.79
11*	29	40	3	1	0.03	0.055	0.20
	29	100	8	1	0.03	0.055	1.32
12	30	70	8	1	0.13	0.055	4.00
13	21	100	3	1	0.03	0.055	0.50
14*	30	50	5	1	0.13	0.055	1.79
	30	100	5	1	0.13	0.055	3.58
	31	80	8	1	0.13	0.055	4.58
	31	100	8	1	0.13	0.055	5.72
15*	33	50	8	1	0.13	0.055	2.86
	32	220	2	1	0.13	0.055	3.15
	34	70	8	1	0.13	0.055	4.00
16	32	80	4	1	0.13	0.055	2.29
17*	35	800	4	1	0.13	0.055	22.88
	38	800	4	1	0.4	0.055	70.40
18	29	50	8	1	0.03	0.055	0.66
19	28	70	4	1	0.03	0.055	0.46
20	30	30	10	1	0.13	0.055	2.15
21	32	20	10	1	0.13	0.055	1.43
22	32	1200	3	1	0.13	0.055	25.74
23	36	30	20	1	0.3	0.055	9.90
24	31	35	20	1	0.13	0.055	5.01
25	34	40	20	1	0.13	0.055	5.72
26	33	30	25	1	0.13	0.055	5.36
27	31	20	20	1	0.13	0.055	2.86
28	27	40	15	1	0.03	0.055	0.99
29	28	45	30	1	0.03	0.055	2.23
30	34	45	15	1	0.13	0.055	4.83
31	27	100	3.5	1	0.03	0.055	0.58
32	28	40	3.5	1	0.03	0.055	0.23
33	30	1100	1.5	1	0.13	0.055	11.80

* Multiple erosion sites may occur at one site location — Total Loss = **272.1**

Savings Made By Restoring Severe Sites (Severity Ranking >=36) = 82.5

Savings Made By Restoring Severe and Moderate (Severity Ranking >29) = 262.7

Total estimated cost to repair all of the streambank erosion sites is estimated to be $156,856 (See Appendix B, Stream inventory)

Road/Stream Crossings

- Utilize the Road/Stream Crossing Inventory to eliminate the "high" and "moderate" priority ranked crossings along Bear Creek and its tributaries. Restore all "high" priority sites during the initial implementation period by 2006 which will reduce the total amount of sediment entering the system by 88.5 tons/year (see Table 19 below).

- Utilize the Road/Stream Crossing Inventory to restore both the "moderate" and "high" priority sites along Bear Creek and its tributaries by 2011. This will reduce the total sediment load by 120 tons/year. Allows for an initial 2 year implementation period to restore severe sites, and an additional 5 years to address remaining moderate and additionally identified severe sites.

Table 19. Road/Stream Crossings and Their Sediment Inputs to the Bear Creek Watershed and Associated Restoration Calculations

Water body	Road/Stream Site	Map Name	Follow-Up Rank	Culvert Ranking	Length (ft)	Height (ft)	Lateral Recession Rate	Dry Density Soil Wt	Total Loss/Yr (tons)
Bear Creek	Whitehall Road	BC2	High	Good	12	20	0.4	0.055	5.28
			High	Good	150	12	0.4	0.055	39.60
	Getty	BC7	Medium	Good	2	2	0.13	0.055	0.03
	Roberts	BC8	Low	Good	1	50	0.03	0.055	0.08
	US 31	BC9	Medium	Good	140	4	0.13	0.055	4.00
			Medium	Good	40	20	0.13	0.055	5.72
			Medium	Good	80	4	0.13	0.055	2.29
Little Bear Creek	River Road	LB3	Medium	Good	7	25	0.13	0.055	1.25
	Russell Road	LB4	Low	Good	25	30	0.03	0.055	1.24
	Tyler Road	LB7	Medium	Good	60	2	0.13	0.055	0.86
	Rail Road X-ing	LB2	High	Requires Immediate Attention	60	15	0.4	0.055	19.80
Bear Lake Direct	Giles	BLD2	High	Good	30	4	0.4	0.055	2.64
Putman-Bard	Bard Road	PB2	Medium	Good	40	2	0.13	0.055	0.57
Pillon-Staple	Staple Road	PS8	Medium	Bad	200	10	0.13	0.055	14.30
	Riley Thompson	PS4	High	Bad	70	4	0.4	0.055	6.16
	Rail Road X-ing	PS5	Low	Good	15	2	0.03	0.055	0.05
	Rail Road X-ing	PS6	Medium	Bad	30	2	0.13	0.055	0.43
	Staple Road	PS7	Medium	Good	15	3	0.13	0.055	0.32
Brandstrom Drain	M-120	BD2	High	Good	300	1.5	0.13	.055	3.22
					900	1.5	0.13	0.055	9.65
	Beatie Road	BD3	High	Good	45	2.5	0.13 - 0.4	0.055	2.19
	Rich Road	BD4	Medium	Good	10	2	0.13	0.055	0.14
Ribe Drain	Michillinda Road	RD4	Medium	Good	20	4	0.13	0.055	0.57
	Rail Road X-ing	RD5	Medium	Good	70	2	0.13	0.055	1.00

Total Loss = **121.4**

Total Savings After Restoring High Priority Sites = 88.5

Total Savings After Restoring High and Medium Priority Sites = 120.0

Total estimated cost to repair all of the road/stream crossing erosion sites is estimated to be $85,564 (See Appendix B, Stream inventory).

Research Needs:

- Additional inventorying of critical areas in the watershed is necessary to further grasp the current and evolving water quality conditions of the watershed, and in particular to monitor the critical areas.
- Development of a buffer system plan for stream and road/stream crossings to mitigate erosion sites and enhance wildlife habitat.
- Additional surveying of riparian landowners, including MDOT and County Road Commission to determine where improvement/repair of road/stream crossings is feasible.

5.3 Watershed Goals and Objectives Summary

In addition to the specific pollutant reduction goals and objectives listed earlier in this chapter there are many other necessary components that are necessary for successful management of the Bear Creek and Bear Lake Watershed.

- Implementation of the Information and Education Strategy (I&E), (Chapter 6, Appendix A), will work toward the goal of increasing public awareness of watershed issues. The I&E will inspire community involvement, ultimately improving stewardship of the watershed.
- Chapter 7 describes the effort to create unified zoning ordinance language that will work toward the protection and restoration of water bodies within the watershed. In addition to working with local units of government on zoning language, Langworthy, Strader, Leblanc, and Associates Inc. (LSL), created a Site Plan Review Guide which provides a set of general rules and procedures regarding the site plan review process, and to tailor that process to the needs of preserving water quality within the Bear Creek and Bear Lake Watershed. This work is a critical component in the attempt to unify zoning ordinance language across township lines, and will create a congruency among watershed communities.
- Specific recommendations for effective stormwater management are laid out in the Stormwater Management Plan in Appendix C. The plan, produced by Conservation Design Forum Inc. (CDF), is a tool that will guide ecologically sound stormwater management decisions within the watershed. It offers practical and realistic solutions that, when implemented, will meet the goal of drastically improving water quality conditions and will deter further degradation by stormwater runoff. It is a valuable tool that can be integrates into master plans, zoning ordinances and the Phase II Stormwater process currently underway.
- A critical component of watershed protection is the adoption of comprehensive stormwater management standards on a regional scale that address stormwater runoff, floodplain management, stream and wetland protection, and soil erosion and sediment control (CDF 2003). The adoption of a countywide stormwater management ordinance would effectively address private development activities

as well as public development activities, and should be applied to both incorporated and unincorporated areas of the county and therefore, watershed. See, Appendix C Stormwater Management Plan section IV for additional and related stormwater regulatory recommendations.

Water Quality goals and objectives, along with overall recommendations for each of the 16 subbasins of the Bear Creek and Bear Lake Watershed, are included in the table below. They have been organized by subwatershed land area based on delineations done by the Michigan Department of Environmental Quality (MDEQ).

Table 20. Subwatershed Summarized Problems and Associated Recommendations

Subbasin Name	Subbasin ID #	Main Problems	Recommendations
Non-Contributing area, West	1	Lack of Awareness/Education	Because these areas are 'non-contributing' additional public education is necessary to improve land/resource management, and to increase awareness of watershed issues and developments. Local government information and education is necessary to promote sound land use decision-making.
Non-Contributing area, Central	2	Lack of Awareness/Education	
Non-Contributing area, East	3	Nutrient Loading, Impervious Surfaces, Lack of Awareness/Education	Identification and reduction of excessive nutrients is necessary (through BMPs and public/local government education) along with sound land use management decision-making. Public should be educated on BMPs and watershed issues.
Upper Bear Creek	4	Thermal pollution, Sedimentation, Lack of Riparian Vegetation, Disruption of historic hydrology, Road/Stream Crossings	Identification of areas where riparian forested buffer BMP can be installed to reduce thermal pollution to the system. Work with County Drain Commission to install forested buffers and improve designated drains. Reduction of nutrient inputs is necessary (through BMPs and public/local government education) along with sound land use decision making. Public education to reduce thermal pollution. Work with County Road Commission to improve road/stream crossing to reduce sedimentation. Restore the historic hydrologic regime by installing wetland areas and preserving open space for water infiltration.
Ribe Drain	5	Thermal pollution, Lack of Riparian Vegetation, Disruption of Historic Hydrology	Identification of areas where riparian forested buffer BMP can be installed to reduce thermal pollution to the system. Work with County Drain Commission to install forested buffers and improve designated drains. Reduction of nutrient inputs is necessary (through BMPs and public/local government education) along with sound land use decision making. Public education to reduce thermal pollution. Restore the historic hydrologic regime by installing wetland areas and preserving open space for water infiltration.
Furman Drain	6	Thermal pollution, Lack of Riparian Vegetation	Identification of areas where riparian forested buffer BMP can be installed to reduce thermal pollution to the system. Work with County Drain Commission to install forested buffers and improve designated drains. Reduction of nutrient inputs is necessary (through BMPs and public/local government education) along with sound land use decision making. Public education to reduce thermal pollution.
Bear Creek to McMillan Road	7	Thermal pollution, Lack of Riparian Vegetation, Nutrient Inputs, Road/Stream Crossings	Identification of areas where riparian forested buffer BMP can be installed to reduce thermal pollution to the system. Work with County Drain Commission to install forested buffers and improve designated drains. Reduction of nutrient inputs is necessary (through BMPs and public/local government education) along with sound land use decision making. Public education to reduce thermal pollution and to reduce excessive nutrient inputs. Work with County Road Commission to improve road/stream crossing to reduce sedimentation and the adoption of construction setbacks should be encouraged.
"Putnam - Bard" Tributary	8	Streambank Erosion, Thermal Pollution	Further identification and repair of streambank erosion sites using BMPs. Identification of areas where riparian forested buffer BMP can be installed to reduce thermal pollution to the system. Work with County Drain Commission to install and improve designated drains.

Subbasin Name	Subbasin ID #	Main Problems	Recommendations
Bear Creek Below McMillan Road	9	Development Pressure (Impervious Surfaces/Stormwater Mgmt), Lack of Awareness/Education	Sound land use management decision-making needs to be encouraged and supported through information and education. The public should be educated on BMPs and watershed specific issues. Additional contacts to landowners interested in implementing conservation practices on their land need to be continually made and the adoption of construction setbacks should be encouraged.
Little Bear Creek	10	Streambank Erosion, Historic Contamination, Development Pressure (Impervious Surfaces/Stormwater Mgmt)	Continual and increased monitoring of groundwater contamination in the unnamed tributary to L. Bear Cr. Sound land use decision making to ensure no further degradation of the subwatershed, and to ensure proper stormwater management during industrial park construction. Identification and repair of streambank erosion sites using associated BMPs.
Bear Creek to Giles Road	11	Development Pressure (Impervious Surfaces/Stormwater Mgmt.), Lack of Awareness/Education	Sound land use management decision-making needs to be encouraged and supported through information and education. The public should be educated on BMPs and watershed specific issues. Additional contacts to landowners interested in implementing conservation practices on their land need to be continually made and the adoption of construction setbacks should be encouraged.
Bear Creek to Getty Road	12	Development Pressure (Impervious Surfaces/Stormwater Mgmt), Streambank Erosion, Stormwater Mgmt./Runoff	Identification and reduction of excessive nutrients is necessary (through BMPs and public/local government education) along with sound land use management decision-making. Public should be educated on BMPs and watershed issues. And Identified streambank erosion sites need to be restored to decrease further sedimentation to the stream and the adoption of construction setbacks should be encouraged.
Bear Creek to Witham Road	13	Development Pressure (Impervious Surfaces/Stormwater Mgmt.), Lack of Awareness/Education	Sound land use management decision-making needs to be encouraged and supported through information and education. The public should be educated on BMPs and watershed specific issues. Additional contacts to landowners interested in implementing conservation practices on their land need to be continually made and the adoption of construction setbacks should be encouraged.
Bear Creek, Laketon Township	14	Nutrient Loading, Development Pressure (Impervious Surfaces/Stormwater Mgmt), Lack of Awareness/Education	Identification and reduction of excessive nutrients is necessary (through BMPs and public/local government education) along with sound land use management decision-making. Public should be educated on BMPs and watershed issues and the adoption of construction setbacks should be encouraged.
Bear Creek, North Muskegon	15	Nutrient loading, Stormwater Mgmt., Lack of Awareness/Education	Identification and reduction of excessive nutrients is necessary (through BMPs and public/local government education) along with sound land use management decision-making. Public should be educated on BMPs and watershed issues.
Bear Lake	16	Nutrient Loading, Sedimentation, Non-native Invasive Species	Research needs to be conducted to determine the trophic condition of the Lake. Integrated Pest Management Practices along with BMPs need to be implemented to better manage the aquatic system to support a vibrant fishery, and to restore the impaired designated uses.

Part II: Activity Summary

Chapter 6 Public Information and Education Activities

A Bear Creek & Bear Lake Watershed Information and Education (I&E) Strategy was developed by the Muskegon Conservation District that targets areas where information and education is lacking and therefore where specific efforts can be implemented to successfully maintain and improve education, awareness, and stewardship of the watershed. This strategy will facilitate partnerships to improve and support local natural resource management programs and educational activities for specified audiences.

The I & E Strategy is based upon information compiled from Bear Creek & Bear Lake Watershed 319 Project's Information and Education Program's focus group meetings and watershed resident surveys. The strategy outlines a path for information and outreach actions necessary to restore, improve, and protect the integrity of the Bear Creek & Bear Lake watershed. It will be used to help plan environmental outreach initiatives and actions, and facilitate partnerships among stakeholder audiences.

Goals and objectives of the I & E Strategy:

1) Increase public awareness and understanding of water quality issues within the watershed and to address the concerns already raised by residents within the Bear Creek & Bear Lake Watershed.
2) Increase the public's participation, responsibility, and stewardship by encouraging participation in watershed projects.
3) Create a partnership among residents and local governments within the Bear Creek & Bear Lake Watershed by sharing ideas and holding activities to increase awareness of watershed management.
4) Encourage the City of North Muskegon and the townships of Dalton, Muskegon, Laketon, and Cedar Creek to develop communication paths and strategies to work together on watershed management practices.

The Bear Creek & Bear Lake I & E Strategy will support ongoing efforts to implement Best Management Practices targeted at specified impaired areas within the watershed. With increased development occurring in the watershed, the actions outlined in I & E Strategy must be implemented in order to protect the watershed's unique natural resources and in order to garner needed public support.

Table 24 lists cost estimates for all the I&E activities outlined in Strategy. The total number of hours required for all activities is estimated to be 1,195 with a materials cost estimated to be $25,050. Staffing costs were estimated using an hourly rate of $20/hr, which would include salaries, fringe benefits, and miscellaneous administrative supplies. The total cost for the implementation of the I & E Strategy is $48,950. The Bear Creek & Bear Lake Watershed I & E Strategy, including a sample survey, focus group meeting summaries, and watershed residents desired uses, is included as Appendix A.

Chapter 7 Land use Congruency and Model Township Ordinance Language

Langworthy, Strader, LeBlanc, and Associates (LSL) Inc. was contracted to develop model zoning ordinances and zoning language for townships within the Bear Creek and Bear Lake Watershed. LSL has much experience with assisting local governments in developing master plans, and ordinances using effective land use planning and natural resource protection. The overall goal of this portion of the project is to improve upon existing land use regulations to improve and protect water quality and to inspire watershed wide stewardship ethics among local decision makers.

There are a total of five municipalities in the Bear Creek and Bear Lake Watershed including: Cedar Creek Township, Dalton Township, Muskegon Township, Laketon Township, and the City of North Muskegon. LSL was already working with Muskegon and Laketon Townships as part of other independent projects with similar water quality protection objectives and recently completed the City of North Muskegon's Zoning Ordinances in 2002. LSL was contracted through the Bear Creek and Bear Lake Watershed 319 Grant Project to work with both Dalton and Cedar Creek Townships. Both Dalton and Cedar Creek townships are rural areas but have recently begun to experience significant population growth, further emphasizing the importance of planning, zoning, and ordinance review to ensure that water quality protections are in place and that environmental issues are justly addressed. Township officials need additional and continual education on what the major water quality concerns and pollutants in their area. Emphasis is placed on future impacts from increased development as well as existing structures in the area. All townships in the watershed should work to update land use procedures to provide better plans for the protection and improvement of water quality in the Bear Creek and Bear Lake Watershed.

Table 21. Townships in the Bear Creek and Bear Lake Watershed and their status regarding master plans and zoning ordinances

County	Township	Land use or Master Plan? Y/N	If yes, date adopted/ updated?	Zoning? Y/N	If yes, date adopted/ updated?
Muskegon	Cedar Creek	Y	2001	Y	1998
	Dalton	Y	2001	Y	1980
	Muskegon Charter	Y	2001	Y	1983
	Laketon	Y	2002	Y	2004
	City of North Muskegon	Y	2002	Y	2002

By using specified Best Management Practices (BMPs) land use planning and zoning tools, local townships have the opportunity to protect and improve water quality conditions in their portion of the watershed. The main goal of this portion of the project was to assist local decision makers protect natural resources in their jurisdiction by addressing their authority through land use planning and zoning ordinances. Township officials have the ability to stem the tide of haphazard development practices, and that their decisions play a critical role in the ecological integrity of the Bear Creek and Bear Lake watershed. Many of the tools and techniques recommended by LSL are in place but modifications to the existing zoning, ordinances, and land use planning practices will strengthen their effectiveness. In addition, LSL's work, if adopted, with neighboring townships ensures congruencies of zoning ordinances language that will aid in the protection of the Bear Creek and Bear Lake Watershed as a whole.

As a part of their work, LSL created a Site Plan Review Guide. The Site Plan Review Guide provides a set of general rules and procedures regarding the site plan review process, and tailors that process to the needs of preserving water quality within the Bear Creek and Bear Lake Watershed. The Guide is intended to be used by planning commissions, legislative bodies, and administrative officials to better acquaint and assist them with issues related to development and site plans that affect water quality. The entire Site Plan review Guide and the recommended Zoning Ordinance language can be found in Appendices D and E.

Part III: Recommendations

Chapter 8 Proposed Implementation Activities in the Bear Creek and Bear Lake Watershed

8.1 Goal of Implementation Activities

The over-arching goal of the Bear Creek and Bear Lake Watershed Project is to protect the surface water and groundwater from pollutants that degrade water quality. This Watershed Management Plan lays the framework for activities and actions to be implemented to reach this goal. It is essential for all landowners, waterfront property owners, and other watershed citizens to work together to protect the water quality of their watershed. The Bear Creek and Bear Lake Watershed Advisory Committee will play a crucial role in disseminating findings, increasing public awareness of both current watershed issues, and implementing management tools (BMPs) that will aid in watershed protection. The implementation of the Information and Education Strategy (Appendix A), and the use of Best Management Practices (BMPs) will ensure the integrity of the Bear Creek and Bear Lake Watershed. In addition the implementation and integration of the Stormwater Management Plan (CDF, 2004) Appendix C, the Site Plan Review Guide Appendix E, and Zoning Ordinance Language Recommendations (LSL, 2004) Appendix D, into regional planning efforts will preserve and protect the watershed from further degradation.

8.2 Information and Education Program

The Bear Creek & Bear Lake I & E Strategy will support ongoing efforts to implement Best Management Practices (BMPs) targeted at specified impaired areas within the watershed. With the increase of development occurring in the watershed, a combination of these actions must be implemented in order to protect the watershed's unique natural resources. This combination of BMPs and the I&E strategy will strengthen the effectiveness of the Bear Creek and Bear Lake Watershed Management Plan. The Bear Creek and Bear Lake Watershed Information and Education Strategy, including a sample survey and watershed residents desired uses, is included as Appendix A.

The I&E Strategy targets areas where information and education is lacking and therefore where specific actions need to be implemented to successfully maintain and improve education, awareness, and stewardship of the Bear Creek and Bear Lake Watershed. The activities listed and information provided will improve and support local natural resource management programs and educational activities for specified audiences to ensure effective outreach methods are undertaken. In addition, this strategy will facilitate partners to interact with target audiences identified in the I & E Strategy.

Table 24 lists cost estimates for all the I&E activities outlined in the Strategy. The total number of staff hours required for all activities is estimated to be 1,195 with a materials cost estimated to be $25,050. Staffing costs were estimated using an hourly rate of $20/hr, which would include salaries, fringe benefits, and miscellaneous administrative supplies. The total cost for the implementation of the I&E Strategy is $48,950.

8.3 Technical Assistance

In order to implement the many projects detailed in the Bear Creek and Bear Lake Management Plan Technical assistance is necessary from a variety of different organizations. Theses agencies would be involved in watershed management activities, installation of best Management Practices, and the Information and Education activities laid out in the I&E Strategy. The following is a list of potential organizations and agencies which can provide technical assistance to residents, landowners, businesses, local townships, and other interested stakeholders:

- Muskegon River Watershed Assembly 231-591-2334
- Michigan Department of Environmental Quality 616-356-0500
- Michigan Department of Natural Resources 517-373-9400
  - Environmental Assistance Center
- USDA Natural Resource Conservation Service 231-773-0008
- Timberland Resource Conservation & Development Area Council 616-784-1090
- Muskegon Conservation District 231-773-0008
- Grand Valley State University – Annis Water Resources Institute 231-728-3601
- Michigan State University Extension Offices 231-724-6361
- Lake Michigan Federation 616-850-0745
- And Other Watershed Project Partners

8.4 Relevant Best Management Practices for the Bear Creek and Bear Lake Watershed

The implementation of Best Management Practices (BMPs) will help prevent and reduce non-point source pollution in the Bear Creek and Bear Lake Watershed. Best Management Practices (BMPs) are structural, vegetative, or managerial practices implemented to protect and improve surface water and groundwater by controlling sources or causes of pollution (MDEQ 2000). To ensure their effectiveness, the correct BMP method needs to be correctly installed and maintained determined by site specific characteristics.

The following list contains BMPs that may be installed during the implementation phase of the Bear Creek and Bear Lake Watershed Project. There are many more BMPs that could potentially be implemented in the watershed and the following list is not exclusive.

It should be noted that continual inventorying and selection of BMP installation sites needs to occur so that BMPs are tailored to the specific need and changing conditions of individual sites. Definitions for the following BMPs are from the MDEQ Guidebook of Best Management Practices for Michigan Watersheds (MDEQ 1998) and the Muskegon River Watershed Management Plan (MRWMP 2002). Anticipated BMPs include, but are not limited, to the following:

Managerial Practices

Critical Area Stabilization - Stabilizing areas that are highly susceptible to erosion by implementing one or more vegetative or structural BMPs. For the purposes of this BMP, critical areas include areas with highly redouble soils, long or steep slopes, droughty soils, excessively wet soils, soils that are very acidic or alkaline, slopes immediately adjacent to water bodies or wetlands, fill areas, and areas subject to concentrated flows.

Integrated Pest Management (IPM) - A process for achieving long term, environmentally sound pest suppression through the use of a wide variety of technological and management practices. Control strategies in an IPM program extend beyond the application of pesticides to include structural and procedural modifications that reduce the food, water, harborage, and access used by pests, such as non-native invasive plants, insects, and organisms.

Fertilizer Management – Addresses the proper selection, use, application, storage, and disposal of fertilizers.

Lawn Maintenance – Includes mowing, irrigating, pesticide and fertilizer management, soil management, and the disposal of organic debris such as lawn clippings, leaves, and pruned branches and twigs.

Slope/Shoreline Stabilization – Addresses structures that stabilize shorelines and slopes that cannot be stabilized with vegetation. Structures include: revetments, gabions, seawalls, bulkheads, groins, breakwaters, and retaining walls.

Runoff Conveyance and Outlets

Check Dams – Constructed across drainages to reduce concentrated flows in the channel and protect vegetation in the early stages of growth; primary purpose is to reduce erosive velocities

Diversion – graded channel and ridge constructed across a slope, perpendicular to the direction of runoff.

Grade Stabilization Structure – permanent structure that stabilizes grades in natural or artificial channels by carrying runoff from one grade to another.

Grassed Waterway – Natural or constructed watercourse consisting of vegetation and designed to accommodate concentrated flow without erosion

Riprap - Permanent cover of rock used to stabilize streambanks, provide in-stream channel stability, and provide a stabilized outlet below concentrated flows.

Streambank Stabilization – Emphasis is places on stabilization at the watershed level first, then individual sites; includes armoring, revetments, riprapping, bioengineering, and streambank protection.

**Additional Stormwater BMPs and their definitions are listed in the Stormwater Management Plan (Appendix C).*

Runoff Storage

Extended Detention Basin – Designed to receive and detain stormwater runoff for a prolonged period of time, typically up to 48 hours, with proper release rates (2 year, 24hour storm events)

Infiltration Basin – Water impoundment over permeable soils that receives stormwater runoff and contains it until it infiltrates the soils.

Construction Sites

Access Road – Graveled areas or pads which allow construction equipment and workers to enter and leave the work site from a public right-of-way, street, alley, sidewalk, or parking area.

Construction Barriers – Fences, signs, and other means used on a construction site to 1)confine equipment and personnel to the immediate construction area, thus minimizing the destruction of vegetation and reducing the potential for erosion and compaction, 2) protect trees and their root zones against abrasion and soil compaction, 3) prevent unnecessary access to structural BMPs, 4) protect sensitive areas, such as water bodies and newly seeded areas, and 5) restrict access of unauthorized persons and vehicles.

Daily Seeding – Establishment of a temporary or permanent vegetative cover by planting cereal grains seeds

Grading – Reshaping the ground surface to planned grades determined by engineering survey evaluation and layout.

Staging – Dividing a construction area into two or more areas to minimize the area of soil that will be exposed at any given time (done to ensure that as much of the site as possible is stabilized)

Scheduling – A planning process that provides a basis for implementing other BMPs in a timely and logical fashion. In any one development, not all BMPs should be implemented at the same time.

Sedimentation Control Structures
Riparian Buffer/Filter Strip – Vegetated area adjacent to a water body (river, wetland, lake) which acts to remove sediment, excess nutrients, organic matter, and other pollutants from runoff water and wastewater (combination of filter to trap sediment/remove pollutants and vegetated buffer to provide shade/leaf litter/erosion control)

Filters – Mechanical methods of removing sediment from storm water before the water leaves a construction site (may consist of pea stones, crushed stone, geotextile material).

Sediment Basin – Man-made depressions in the ground where runoff water is collected and stored to allow suspended solids to settle out

Watercourse Crossings – Structures which cross creeks, stream, or other surface areas of open water that are used to provide a more confined and environmentally sensitive means for crossing from one side of a watercourse to another (may be above or below the water surface)

Vegetative Establishments
Mulching – Process of placing a uniform layer of straw, wood chips or other acceptable material over a seeded are to allow immediate protection for a seed bed.

Seeding – Establishment of a temporary or permanent vegetative cover by planting seed

Soil Management – Managing soil to proved the best growing conditions for turf and other vegetation.

Wetlands
Constructed Wetland Use in Storm Water Control – Excavated basins with irregular perimeter and undulating bottom contours into which wetland vegetation is purposely placed to enhance pollutant removal from stormwater runoff.

Recreation Trail and Walkway
A pathway prepared especially for pedestrian, equestrian, and cycle travel.

Agricultural Best Management Practices
These are additional BMPs for agricultural areas, which are not included in the list above. It should be noted that there are many more agricultural BMPs that exist than what is listed here, for a complete list contact local USDA-NRCS offices/representatives. This list and their descriptions are from the Natural Resources Conservation Service Technical Guide, Section IV.

Fencing – Enclosing or dividing an area of land with a suitable permanent structure that acts as a barrier to livestock, big game, or people.

Conservation Crop Rotation – Growing crops in a recurring sequence on the same field

Cover and Green Manure Crop – A crop of close-growing grasses, legumes, or small grain used primarily for seasonal protection and soil improvement. It usually is grown for 1 year or less, except where there is permanent cover as in orchards.

Critical Area Planting - Planting vegetation such as trees, shrubs, vines, grasses, or legumes on areas particularly susceptible to soil erosion

Crop Residue management – Leaving last year's crop residue on the soil surface buy limiting tillage (includes no-till, and ridge till).

Field Border – A strip of grass or legumes in a contoured field, which will help trap nutrients and sediment.

Nutrient Management – Managing the amount, form, placement, and timing of applications of plant nutrients

Pest Management – Managing agricultural pest infestations (including weeds, insects, and diseases) to reduce adverse effects on plant growth, crop production and environmental resources.

Residue Management, Mulch Till - Managing the amount, orientation, and distribution of crop and other plant residue on the soil surface year-round, while growing crops in previously untilled soil and residue.

Riparian buffer Strips – An area of trees, shrubs, and other vegetation located in areas adjacent to and up gradient from water bodies such as: lakes, rivers, streams, agricultural drains.

Waste Management System – A planned system in which all necessary components are installed for managing liquid and solid waste, including runoff from concentrated waste areas, in a manner that does not degrade soil, water, air, plant or animal resources.

Waste Utilization – Using agricultural or other wastes on land in an environmentally acceptable manner while maintaining or improving soil and plant resources.

Road/Stream Crossing Improvements
The following list of BMPs may be involved in repairing road/steam crossings, but is not limited to: grading, tree removal, paving of gravel roads, spillways, stone riprap and check dams, slope stabilization, and installation and maintenance of temporary soil erosion controls.

8.5 Suggested Best Management Practices for Implementation in the Bear Creek and Bear Lake Watershed

Specific BMPs and their costs were estimated for the entire Bear Creek and Bear Lake Watershed. The number/area of proposed BMPs to be installed in each area was estimated based upon the findings from the road/stream crossing inventory, streambank surveys, site visits with property owners, GIS data, and other physical inventories. Cost estimates for each BMP were based upon cost estimates from USDA-NRCS conservationist. Costs of labor to implement the BMPs were not included with the estimates because of the variation that exists between volunteer labor, and contractor labor fees.

All BMPs are recommended to be installed in order to fulfill the water quality goals stated in Chapter 5. The implementation of the necessary BMPs will ensure pollutant reduction goals are met. The number of structures identified in the table below was determined by field observations and will repair existing sources of contamination in the Bear Creek and Bear Lake watershed. Estimated additional sites for BMP structure installation are estimates of occurring, but unidentified sources of pollution in the watershed. Table 22 below lists necessary BMPs for installation to restore, improve, and protect the State designated Uses and the estimated costs for repair. Table 23 details pollutant reduction expected after BMP installation and also lists associated measures of success and technical resources needed for implementation.

Table 22. Recommended BMPs for Implementation in the Bear Creek and Bear Lake Watershed and Associated Costs

BMP	Number of Structures Identified	Quantitative Estimates for Additional Sites	Area to be Installed (Identified / Additional)	Estimated Costs for Each	Estimated Costs to Repair Identified Sites	Estimated Costs to Repair Additional Sites	Estimated Total Labor Costs	Grand Total (Identified & Additional & Labor)
Grade Stabilization Structures	21	8	See Stream Bank Inventory (Appendix C)		$60,255.00	$22,954.28	$1,600.00	$84,809.28
Riparian Forest Buffer	7	11	22.5 acres / 12.5 acres	$900 / acre	$20,250.00	$11,250.00	$3,200.00	$34,700.00
Riparian Forest Buffer Management	7	11	22.5 acres / 12.5 acres	$225 / acre	$5,062.50	$2,812.50		$7,875.00
Filter Strip	15		9 acres	$500 / acre	$4,500.00		$3,200.00	$7,700.00
Filter Strip Management	15		9 acres	$150 / acre	$1,350.00			$1,350.00
Streambank Stabilization	53	19	4747' / 1700'	~$37 / ft	$174,745.00	$62,900.00	$23,040.00	$260,685.00
Watercourse Crossing	2	2	30 ft / 30 ft	$3,710 each	$7,420.00	$7,420.00	$2,400.00	$17,240.00
Stormwater Infiltration	3	2	10 acres	$25,000 each	$75,000.00	$50,000.00	$8,000.00	$133,000.00
Constructed Wetlands	7	8	14 / 16 acres	$1,500 / acre	$21,000.00	$24,000.00	$48,000.00	$93,000.00
Resource Management System (RMS) Plans	20	25	TBD	8hrs at $50/hr each			$10,000.00	$10,000.00
Sediment Basin	3	1	TBD	$3,500 each	$11,500.00	$3,500.00	$1,280.00	$16,280.00
Invasive Species Control	12	24	50 acres / 100 acres	$400 / acre	$20,000.00	$40,000.00	$5,760.00	$65,760.00
Shoreline Filter Strip	2 installed	40	200 ft / 4000 ft	.60 / ft		$2,400.00	$38,400.00	$40,800.00
Trailways / Boardwalk	2	4	3,500 ft / 2,000 ft	$22 / ft	$77,000.00	$44,000.00	$84,480.00	$205,480.00
TBD = To be Determined			**Grand Total =**		$478,082.50	$271,236.78	$229,360.00	**$978,679.28**

Labor based on $20/hr

Table 23. Recommended BMPs and the Pollutant Reduction Amounts Expected Linked With the State Designated Uses to Restore, Improve, or Protect.

BMP	Number of Structures Identified	Area to be Installed (Identified)	Pollutant to Reduce	Expected Load Reduction	Measure of Success	Designated Use to Restore(R), Improve (I) or Protect (P)	Resources
Grade Stabilization Structures	21	See Stream Bank Inventory (Appendix C)	Sediment	78.65 tons/year	Severe Sites Completed by end of Year 2 Moderate and Additional Severe by end of Year 7	Coldwater Fishery (R), Aquatic Life and Wildlife(R), Warmwater Fishery(I), Navigation(I)	NRCS, Drain Commission, MCD, GLC
Riparian Forest Buffer (Including Management)	7	22.5 acres	Temperature	Lowering by 4.6 C	Installation Initiated in Year 2	Coldwater Fishery (R), Aquatic Life and Wildlife(R), Warmwater Fishery (I), Navigation(I), Partial and Total Body Recreation (R), Public Water Supply (P)	USFS, MDNR, MCD, NRCS, Drain Commission,
			Sediment	105 - 632 tons/yr			
			Excess Nutrients	>90% of nitrate and attached phosphorous from installation sites			
			Toxic Substances	>90% of attached toxic contaminants from installation sites			
Filter Strip (Including Management)	15	9 acres	Temperature	Lowering by 1.49 C	Installation Initiated in Year 2	Coldwater Fishery (R), Aquatic Life and Wildlife(R), Warmwater Fishery (I), Navigation(I), Partial and Total Body Recreation (R), Public Water Supply (P)	NRCS, USFS, MCD, Pheasants Forever, TU, MDNR,
			Sediment	253 tons/yr			
			Excess Nutrients	>90% of nitrate and attached phosphorous from installation sites			
			Toxic Substances	>90% of attached toxic contaminants from installation sites			
Streambank Stabilization	53	4747'	Sediment	306.32 tons/year	Severe Sites Completed by end of Year 2 Moderate and Additional Severe by end of Year 7	Coldwater Fishery (R), Aquatic Life and Wildlife(R), Warmwater Fishery (I), Navigation(I)	NRCS, MCD, Drain Commission, Road Commission, GLC, MDEQ
Watercourse Crossing	2	30 ft	Sediment	15.1 tons/year	Installed by Year 2	Coldwater Fishery (R), Aquatic Life and Wildlife(R), Warmwater Fishery(I), Navigation(I)	NRCS, MCD, MDEQ
Stormwater Infiltration	3	10 acres	Temperature	Depends on Type of Drainage Area Surface	Installation Completed by Year 2	Coldwater Fishery (R), Aquatic Life and Wildlife(R), Warmwater Fishery (I), Navigation(I), Partial and Total Body Recreation (R), Public Water Supply (P)	NRCS, MCD, Drain Commission, Muskegon County, MDEQ
			Sediment	100% of 2yr Storm event (2.6"/24hrs)			
			Excess Nutrients	100% of 2yr Storm event (2.6"/24hrs)			
			Toxic Substances	100% of 2yr Storm event (2.6"/24hrs)			
Constructed Wetlands	7	14 acres	Toxic Substances	100%	Construction Completed by Year 7	Coldwater Fishery (R), Aquatic Life and Wildlife(R), Warmwater Fishery (I), Navigation(I), Partial and Total Body Recreation (R), Public Water Supply (P)	NRCS, MDEQ, DU, MCD, MDNR, USFWS, TNC
			Excess Nutrients	Depends on plant abundance			
Resource Management System (RMS) Plans	20	TBD			50% Initiated by Year 2		NRCS, MCD(Forester)

BMP	Number of Structures Identified	Area to be Installed (Identified)	Pollutant to Reduce	Expected Load Reduction	Measure of Success	Designated Use to Restore(R), Improve (I) or Protect (P)	Resources
Sediment Basin	3	TBD	Sediment	>90% of sediment removed from watercourse	Installation Completed by Year 2	Coldwater Fishery (R), Aquatic Life and Wildlife(R), Warmwater Fishery(I), Navigation(I)	NRCS, Drain Commission, MCD, GLC
Invasive Species Control	12	50 acres	Invasive Species		Initiated in Year 1 - Ongoing	Aquatic Life and Wildlife (R), Navigation (I)	NRCS, MCD, TNC, MDA
Shoreline Filter Strip	2 installed	200 ft	Temperature	Lowering by 1 C	50% Completed by Year 7	Coldwater Fishery (R), Aquatic Life and Wildlife(R), Warmwater Fishery(I), Navigation(I), Partial and Total Body Recreation (R), Public Water Supply (P)	MCD, NRCS, Ducks Unlimited, BLA, MDNR, MDEQ, City of North Muskegon
			Sediment	13 tons/yr			
			Excess Nutrients	>90% of nitrate and attached phosphorous			
			Toxic Substances	>90% of attached toxic contaminants from installation sites			
Trailways / Boardwalk	2	3,500 ft	Sediment	225 tons/yr	Initiated in Year 1	Coldwater Fishery (R), Aquatic Life and Wildlife(R), Warmwater Fishery(I), Navigation(I)	MCD, NRCS, MDEQ, Rails to Trails Conservancy, MDNR

Based on identified sites only, additional areas, erosion sites, and site dimensions have not been evaluated to date.

8.6 Information and Education Program

With development pressure encroaching on the land area of the Bear Creek and Bear Lake Watershed, Best Management Practices need to be implemented in conjunction with an Information and Education(I & E) Strategy. The combination of the two will strengthen the Watershed management Plan and will ensure its effectiveness by beginning a public awareness and education campaign while also addressing community concerns. As mentioned earlier in Chapter 6, a Bear Creek and Bear Lake Watershed I & E Strategy was developed to address the actions needed to successfully maintain and improve community involvement, watershed education, awareness, and stewardship of the watershed (Appendix A).

The following table lists the cost estimates for all activities proposed in the I & E Strategy. The total costs for the implementation of the strategy is 25,050 for materials, and $23,900 for labor costs. Personnel costs were estimated using an hourly wage of $20/hour which would include salaries, fringe benefits, and incidental supplies. The total costs for all activities including materials and staffing costs is $48,950.

Table 24. Cost for Implementation of the Information and Education Strategy for the Bear Creek and Bear Lake Watershed

I&E Activities	Quantity	Cost	Total Hours	Cost w/Staffing
Watershed Brochures	2500	$2500	40	$3,300
Newsletters	12000	$12000	320	$18,400
Watershed Posters	50	$250	30	$850
Watershed Tours	2	$1500	40	$2,300
Watershed Festival	2	$2000	150	$5,000
Promotional Materials	200	$2000	75	$3,500
Public Meetings	8	$800	160	$4,000
Adopt –A- Watershed	2	$1000	100	$3,000
Site Cleanups	5	$2000	200	$6,000
Storm Drain Stickering	500	$1000	80	$2,600
Total =		**$25,050**	**1195**	**$48,950**

8.7 Implementation Summary

The implementation activities detailed in this chapter lay the framework for actions to be implemented to reach the goal of improving water quality in the Bear Creek and Bear Lake Watershed. BMP installation will satisfy pollutant reduction needed to protect, improve, and restore the State Designated Uses. Initiation of the I&E activities will encourage all landowners, waterfront property owners, and other watershed citizens to work together to protect the water quality of their watershed. Table 25 below lists all recommended BMPs and I&E activities described throughout this watershed management plan with the associated cost share rates, amounts, and local match needed for successful implementation.

Table 25. Implementation Summary Including Recommended BMPs, I&E Strategy, and Associated Cost Share Amounts

Implementation Activity	Estimated Costs to Repair Identified Sites	Estimated Costs to Repair Additional Sites	Area to be Installed/Amount (Identified / Additional)	Estimated Costs for Each	Cost Share Rate	Amount Cost Shared	Local Match Amount	Grand Total (Identified & Additional & Labor)
BMPs								
Grade Stabilization Structures	$60,255.00	$22,954.28	See Stream Inventory (Appendix C)		75%	$63,606.96	$21,202.32	$84,809.28
Riparian Forest Buffer	$20,250.00	$11,250.00	22.5 acres / 12.5 acres	$900 / acre	75%	$26,025.00	$8,675.00	$34,700.00
Riparian Forest Buffer Management	$5,062.50	$2,812.50	22.5 acres / 12.5 acres	$225 / acre	0%	$0.00	$7,875.00	$7,875.00
Filter Strip	$4,500.00		9 acres	$500 / acre	75%	$5,775.00	$1,925.00	$7,700.00
Filter Strip Management	$1,350.00		9 acres	$150 / acre	0%	$0.00	$1,350.00	$1,350.00
Streambank Stabilization	$174,745.00	$62,900.00	4747' / 1700'	~$37 / ft	75%	$195,513.75	$65,171.25	$260,685.00
Watercourse Crossing	$7,420.00	$7,420.00	30 ft / 30 ft	$3,710 each	75%	$12,930.00	$4,310.00	$17,240.00
Stormwater Infiltration	$75,000.00	$50,000.00	10 acres	$25,000 each	75%	$99,750.00	$33,250.00	$133,000.00
Constructed Wetlands	$21,000.00	$24,000.00	14 / 16 acres	$1,500 / acre	75%	$69,750.00	$23,250.00	$93,000.00
Resource Management System (RMS) Plans			TBD	8hrs at $50/hr each	0%	$0.00	$10,000.00	$10,000.00
Sediment Basin	$11,500.00	$3,500.00	TBD	$3,500 each	75%	$12,210.00	$4,070.00	$16,280.00
Invasive Species Control	$20,000.00	$40,000.00	50 acres / 100 acres	$400 / acre	75%	$49,320.00	$16,440.00	$65,760.00
Shoreline Filter Strip		$2,400.00	200 ft / 4000 ft	.60 / ft	75%	$30,600.00	$10,200.00	$40,800.00
Trailways/Boardwalk	$77,000.00	$44,000.00	3,500 ft / 2,000 ft	$22 / ft	75%	$154,110.00	$51,370.00	$205,480.00
BMPs Sub Total =	$478,082.50	$271,236.78				$719,590.71	$259,088.57	$978,679.28
I & E Strategy	**Amount Identified**		**Amount**					
Watershed Brochures	2,500.00		2500	$1 / each	75%	$2,475.00	$825.00	$3,300.00
Newsletters	12,000.00		12000	$1 / each	75%	$13,800.00	$4,600.00	$18,400.00
Watershed Posters	250.00		50	$5 / each	75%	$637.50	$212.50	$850.00
Watershed Tours	1,500.00		2	$750 / each	75%	$1,725.00	$575.00	$2,300.00
Watershed Festival	2,000.00		2	$1000 / each	75%	$3,750.00	$1,250.00	$5,000.00
Promotional Materials	2,000.00		200	$10 / each	75%	$2,625.00	$875.00	$3,500.00
Public Meetings	800.00		8	$100 / each	75%	$3,000.00	$1,000.00	$4,000.00
Adopt -A-Watershed	1,000.00		2	$500 / each	75%	$2,250.00	$750.00	$3,000.00
Site Cleanups	2,000.00		5	$400 / each	75%	$4,500.00	$1,500.00	$6,000.00
Storm Drain Stickering	1,000.00		500	$2 / each	75%	$1,950.00	$650.00	$2,600.00
I&E Strategy Subtotal=	$25,050.00					$36,712.50	$12,237.50	$48,950.00
BMPs Subtotal =	$478,082.50	$271,236.78				$719,590.71	$259,088.57	$978,679.28
Grand Total =						**$756,303.21**	**$271,326.07**	**$1,027,629.28**

TBD = To be Determined

A schedule for implementing the non-point source pollution actions recommended throughout this management plan is necessary so that work is initiated and expedited in a timely manner. The table below lists the necessary implementation activities to improve water quality in the Bear Creek and Bear Lake Watershed with dates for initiation and completion.

Table 26. Implementation Activities Schedule

Implementation Activity	Quantity	Implementation
BMPs		
Grade Stabilization Structures	21	Severe Sites Completed by end of Year 2
		Moderate and Additional Severe by end of Year 7
Riparian Forest Buffer (including Management)	7	Installation Initiated in Year 2
Filter Strip (including Management)	15	Installation Initiated in Year 2
Streambank Stabilization	53	Severe Sites Completed by end of Year 2
		Moderate and Additional Severe by end of Year 7
Watercourse Crossing	2	Installed by Year 2
Stormwater Infiltration	3	Installation Completed by Year 2
Constructed Wetlands	7	Construction Completed by Year 7
Resource Management System (RMS) Plans	20	50% Initiated by Year 2
Sediment Basin	3	Installation Completed by Year 2
Invasive Species Control	12	Initiated in Year 1 - Ongoing
Shoreline Filter Strip	40*	50% Completed by Year 7
Trailways / Boardwalk	2	Initiated in Year 1
I & E Strategy		
Watershed Brochures	2500	Completed by Year 1
Newsletters	12000	Completed by Year 2
Watershed Posters	50	Completed by Year 1
Watershed Tours	2	Annually Year 1 & Year 1
Watershed Festival	2	Annually Year 1 & Year 2
Promotional Materials	200	Initiated in Year 1
Public Meetings	8	Initiated in Year 1 - Ongoing
Adopt –A- Watershed	2	Initiated in Year 1
Site Cleanups	5	Annually Year 1 & Year 2
Storm Drain Stickering	500	Initiated in Year 1

Based on identified sites only, additional areas, erosion sites, and site dimensions have not been evaluated to date.

* Additional Sites

Chapter 9 Bear Creek and Bear Lake Watershed Project Evaluation

An evaluation of the Bear Creek and Bear Lake Watershed Project is necessary in order to ensure the effectiveness and success of the Plan in reaching its goals and objectives for water quality improvement. Evaluations improve the way that projects deliver services, improve project management, and assist the project director see problems more clearly. The overall success is contingent upon community involvement, and the support and participation from all interested parties in the region. With little public commitment toward protection and preservation of the Bear Creek and Bear Lake Watershed, the Project will be much more unlikely to reach its goals and objectives. The number of landowners who participate in cost-sharing programs and follow through with the Resource Management System (RMS) plans, can provide an indication of the degree of success the project may have in the long term.

The following measures will aid in evaluating the project success by providing feedback to ensure the efficiency of further management efforts long after the implementation phase of the project is completed.

1. Public Surveys
2. Stream Monitoring
3. Best Management Practices – Follow up
4. Workshops, Public Meetings
5. Bear Creek/Lake Watershed Advisory Committee Meetings
6. Adopt*A*Watershed Program

Evaluation is an integral component of the implementation phase of the Bear Creek and Bear Lake Watershed Project. It will help managers to measure project accomplishments in areas such as changes in people's attitudes and perceptions about water quality issues, the project's impact on local decision makers/policy development, and the sustainability of the program beyond the current funding stream. A public input "Before" survey was created in accordance with the MDEQ approved Quality Assurance Project Plan (QAPP), and was sent to a subset of 519 watershed residents. In addition to gathering desired uses for the Bear Creek and Bear Lake Watershed, the survey gathered valuable information of the general public's awareness and knowledge of water quality issues and conditions. A survey provides statistical data and valuable information regarding the community's perception toward the project. This survey helped project staff cater education and outreach activities during the project where information and education was most needed, and was instrumental in the creation of the I&E Strategy (Appendix A). An "After" survey, which is identical to the original, was sent out to the same subset of watershed residents to evaluate the project's education and outreach campaign success and to further

identify the watershed residents desired uses and I&E needs. Results from the "after" survey will help guide future information and education activities, and ensure their effectiveness. These activities are outlined in the I & E Strategy and are to be implemented during the Implementation Phase of the project.

Initial and continual monitoring of the biological, hydrological, and chemical conditions of the system will provide useful information to evaluate the overall success of this project. Michigan Department of Environmental Quality (MDEQ), Michigan Department of Natural Resources (MDNR), and water quality monitoring volunteers have been instrumental in establishing a continual monitoring effort. It should be noted that much more monitoring needs to take place to further grasp the current and evolving water quality conditions of the watershed. As more development occurs in the watershed the potential for negative impacts to water quality and the integrity of the system increases. Results from water quality monitoring will often illustrate improvements/successes of implementation efforts, or which areas in the watershed to focus on.

Follow up efforts will be made to monitor individual Best Management Practices (BMPs) at various locations in the watershed during the implementation period to determine the effectiveness of each particular practice. The success of the BMPs will be tracked by the total number of BMPs implemented, their overall impact based on location, and their overall effectiveness on improving water quality in the Bear Creek and Bear Lake Watershed. Overall impact to water quality will be determined by comparing to date data with initial monitoring efforts. Changes and adjustments will be made accordingly with assistance from the USDA-Natural Resources Conservation Service (NRCS). In addition, Resource Management System Plans, completed by the USDA-NRCS and District Forester, will be implemented according to RMS plan specifications, with before and after effects, and quantities evaluated for effectiveness as part of the implementation phase.

Workshops, seminars, and public meetings are planned as part of the I&E Strategy during the implementation period. In addition to offering excellent information and education on watershed specific issues, these activities foster communication among and between watershed residents and a diverse stakeholder group. The number of community members that attend such events and their input and comments will be used to evaluate the effectiveness of outreach activities.

Bear Creek and Bear Lake Watershed Advisory Committee meetings will be held on average every other month to monitor progress and keep the Watershed Project moving forward and in line with stated goals and objectives. Committee members will comment and suggest ideas to make the project more effective and successful in the long term by including the public in resource management decisions. Committee members and the Project Manager will correspond with MDEQ to ensure project success if a MDEQ representative is not present.

The Adopt*A*Watershed program is another method that can be used to effectively measure the success of the Bear Creek and Bear Lake Watershed Project. A complete Adopt*A*Watershed program is planned for the implementation period of the project which would involve many groups in conservation activities that will ultimately increase awareness and improve water quality. The degree of public participation will act as an indicator of the community's willingness to restore, improve, and protect the ecological integrity of the Bear Creek and Bear Lake Watershed.

Chapter 10 Future Efforts in the Bear Creek and Bear Lake Watershed

It is anticipated that funding for the implementation phase of the Bear Creek and Bear Lake Watershed Project through Section 319 funds will be available upon Plan approval. These initial funds will be a part of the goal to implement all project needs, and it is expected that the implementation phase will last approximately two years. Grant funds will be used to continue watershed assessment activities and inventorying of critical areas, design and install BMPs, and complete the I&E strategy. The Bear Creek and Bear Lake Watershed Advisory Committee and the Project Steering Committee will continue to meet throughout the implementation phase of the project.

The Information and Education (I&E) Strategy will act as a tool for educators, decision makers, and interested residents. It provides activities to increase public awareness and involvement with, and knowledge of, historic, current, and future watershed issues. Based upon findings from both the 'before' and 'after' mailed surveys, the I&E Plan targets specific audiences where information and education is lacking with the overall goal to improve water quality in the watershed through effective stewardship. It is to educate and inform the vast variety of people that live, work, and play within the Bear Creek & Bear Lake Watershed. Implementation of the I&E Strategy will commence in the Summer of 2004 and is anticipated to last two years. The Bear Creek and Bear Lake Watershed Advisory Committee will continue to partner with the Muskegon Conservation District to carry out I&E activities during and after the project period is completed. Estimated costs for the implementation of the I&E Strategy is $48,950.

Through the Information and Education campaign additional partnerships among area agencies and landowners will encourage further design and installation of BMPs. Education efforts will be targeted toward riparian landowners, local units of government, and other watershed residents in order to educate them on the impacts individual land uses may have on water quality. In addition, information on Best Management Practices best suited for their own backyards will be disseminated. Local decision makers will be informed on the impacts of land use decisions have on the watershed. Local decision makers have authority through land use planning and zoning ordinances to impact the Bear Creek and Bear Lake watershed's water quality. Some officials are unaware of their ability to stem the tide of haphazard development practices. These decisions play a critical role in the preservation of the ecological integrity of Bear Creek, Bear Lake and their tributaries. Once landowners, decision makers, and other watershed residents are informed of the issues and alternative solutions, the implementation of various structural and managerial BMPs will begin. The total estimated costs for the implementation of these BMPs is $978,679.28.

Additional inventorying of critical areas in the watershed is necessary to further grasp the current and evolving water quality conditions of the watershed, and in particular to monitor the identified critical areas. As additional sources of pollutants are discovered, the need for specific BMPs along with the I&E efforts will be studied. Specific recommendations for I&E activities and BMPs to be implemented are listed in Table 25. Partnerships with local agencies, landowners, and community groups will be explored to further the development and implementation of BMPs. BMPs will be planned by project partners and staff, while engineering work will be contracted to ensure proper practice, installation, and maintenance.

The critical area designation portion of the Bear Creek and Bear Lake Watershed Project represents one of the more instrumental tools for future protection and conservation projects in the watershed. The critical areas map (Figure 19) that was created can be used as a guide to highlight areas that are currently contributing pollutants to the system, but to also shed needed light onto those areas that may be most susceptible to become sources of nonpoint source pollution if environmentally sound development and land use practices do not occur in the watershed. The Bear Creek and Bear Lake Watershed must be continually monitored to assess environmental conditions in the watershed. This monitoring effort will increase in effectiveness as more watershed residents get involved, and will aid resource managers in evaluating the Watershed Projects success.

Part IV: Conclusions

Chapter 11 Final Comments

The Bear Creek and Bear Lake Watershed Management Plan was initiated to address the non-point source pollutants and water quality concerns. As a result of the two-year planning phase, many of the key stakeholders in the watershed, i.e., local decision makers, organizations, agencies, and local residents gained a better understanding of the dynamics of the Bear Creek Watershed and its relation to the Muskegon Lake Area Of Concern (AOC). This watershed management plan is an impetus for further growth in understanding the complex interactions that make up the watershed, will guide action during the implementation phase of the project, and is a practical tool in addressing past, current, and future water quality threats to the watershed.

Four of the State designated uses for the Bear Creek & Bear Lake Watershed are impaired including: Coldwater fishery, Aquatic life and wildlife, Partial body contact recreation, and Total body contact recreation. In addition, two of the designated uses in the watershed are threatened. Threatened water bodies are defined as those that currently meet water quality standards but are under the threat of not meeting those standards in the future, these include: Warmwater fishery, and Navigation. The impaired and threatened uses were ascertained through field inventories of suspected pollutants, MDEQ, and water quality reports.

Excessive sedimentation, nutrient loadings, thermal pollution, and toxic substances are pollutants that are negatively impacting the designated uses. These pollutants and other suspected pollutants degrade water quality, destroy aquatic habitat, and reduce the abundance and diversity of aquatic life, while preventing recreational enjoyment. A list of known, suspected, and potential pollutants was compiled along with specific pollution reduction goals to restore and improve the designated uses. The list will guide resource management actions to the goal of protecting the ecological integrity of the watershed.

The Bear Creek and Bear Lake Watershed Management Plan provides an outline for necessary management activities as well as ways to reduce negative impacts from non-point source pollutants. This plan is designed to assist local decision makers, residents, landowners, and other stakeholders in the watershed to make ecologically sound decisions to improve and protect the water quality of the watershed.

Continual inventorying and monitoring of the watershed needs to take place so that new sites can be identified and Best Management Practices selected to remedy the specific site characteristics. Identified pollution concerns in the watershed were addressed using BMPs, and a list is provided as a toolbox for reference.

A Bear Creek and Bear Lake Watershed Information and Education (I&E) Strategy was developed to target areas where information and education is lacking. Specific efforts are

recommended for implementation to successfully maintain and improve education, awareness, and stewardship of the watershed. This information will improve and support local natural resource management programs and educational activities for specified audiences. In addition, this strategy will facilitate partners to interact with target audiences identified in the I & E Strategy, and lists activities to be implemented in the watershed. The costs for the I&E to be implemented is estimated at $48,950.

Additional effort and correspondence needs to be undertaken to ensure that zoning ordinance language is adapted toward the protection and restoration of water bodies within the watershed. The Site Plan Review Guide (SPR), created by LSL, provides a set of general rules and procedures regarding the site plan review process, and tailors that process to the needs of preserving natural resources within the Bear Creek and Bear Lake Watershed. The SPR should be integrated with current site plan review tools.

Specific recommendations for effective stormwater management are laid out in the Stormwater Management Plan in Appendix C. The plan, produced by Conservation Design Forum Inc. (CDF), is a tool that will guide ecologically sound stormwater management decisions within the watershed. It offers practical and realistic solutions to improve water quality conditions and will deter further degradation by stormwater runoff. It is a valuable tool that can be integrates into master plans, zoning ordinances and the Phase II Stormwater process currently underway. In addition, the adoption of comprehensive stormwater management standards on a regional scale that address stormwater runoff, floodplain management, stream and wetland protection, and soil erosion and sediment control is necessary. The adoption of a countywide stormwater management ordinance would effectively address private development activities as well as public development activities, and should be applied to both incorporated and unincorporated areas of the county and therefore, watershed.

Total cost for the Implementation of all recommended BMPs and I&E activities is $1,027,629.28 (See Table 25).

Works Cited

Annis Water Resources Institute, Grand Valley State University. Muskegon River Watershed Management Plan. August 2002.

Conservation Design Forum (CDF). Bear Creek and Bear Lake Stormwater Management Plan. 2004

Doppelt, Bob, et al. (The Pacific Rivers Council). Entering the Watershed: A New Approach to Save America's River Ecosystems. Washington, D.C.: Island Press, 1993.

Michigan Department of Agriculture (MDA). Climatology Program. Michigan State University. 417 Natural Sciences Building. East Lansing, MI. 48824. http://35.9.73.71

Michigan Department of Environmental Quality (MDEQ). 1998. Guidebook of Best Management Practices for Michigan Watersheds. Lansing, Michigan. (Reprint 2001)

Michigan Department of Environmental Quality (MDEQ). February 2000. Developing a Watershed Management Plan for Water Quality, An Introductory Guide. 52pp.

Michigan Department of Environmental Quality (MDEQ). 2002. Water Quality and Pollution Control in Michigan. 2002 Section 305(b) Report. Report # MI/DEQ/SWQ-02/024.

Michigan Department of Environmental Quality (MDEQ). 2002. Clean Water Act Section 303(d) List. Report # MI/DEQ/SWQ-02/013.

Michigan Department of Environmental Quality (MDEQ), Hydrologic Studies Unit – Geological and Land Management Division. 2003. Bear Creek Watershed Hydrologic Study. 30pp.

Michigan Department of Natural Resources (MDNR). 2002. Michigan Family Fish Consumption Guide. Michigan Department of Natural Resources, Fisheries Division.

Michigan Department of Natural Resources (MDNR). 2002. Inland Trout & Salmon Guide. Michigan Department of Natural Resources, Fisheries Division.

Michigan Department of Natural Resources (MDNR), Surface Water Quality Division. Agricultural Best Management Practices for Michigan's Nonpoint Source Pollution Program. 1991.

Michigan Natural Features Inventory (MNFI). 2003. Webpage: Watershed Element Data: Muskegon County. http://web4.msue.msu.edu/mnfi/data/watshd_dat.cfm?id=4060102%2022%2039

Muskegon Conservation District (MCD). 2002. Muskegon Lake Community Action Plan, 2002 Remedial Action Plan Update. 51pp.

Oceana Conservation District. South Branch of the Pentwater River Nonpoint Source Watershed Management Plan. October 1999.

O'Neal, Richard P. 1997. Muskegon River Watershed Assessment. State of Michigan Department of Natural Resources. Fisheries Division Special Report No. 19.

Satterlund, Donald R. and Paul W. Adams. Wildland Watershed Management (Second Edition). New York: John Wiley & Sons, Inc., 1992.

Sayles, Brenda. Designated Uses for Michigan Water bodies. Michigan's Nonpoint Source News. Michigan Department of Environmental Quality, Summer 1996.

Timberland Resource Conservation & Development. Pigeon River Comprehensive Nonpoint Source Watershed Management Plan. August 1997.

United States Census Bureau. 2003. Webpage: Census Data: Muskegon County. http://www.census.gov

United States Department of Agriculture. 1968. Soil Survey, Muskegon County Michigan. 1-89.

United States Department of Agriculture (USDA), Natural Resource Conservation Service (NRCS). Section IV of the Technical Guide. 1999.

United States Environmental Protection Agency (USEPA). 2002. Webpage: NPL Fact Sheets for Michigan. Duell and Gardner Landfill. http://www.epa.gov/R5Super/npl/michigan/MID980504716.htm

United States Environmental Protection Agency (USEPA). 2002. Webpage: NPL Fact Sheets for Michigan. Ott/Story/Cordova Chemical CO. http://epa.gov/reg5sfun/sfd/npl/michigan/MID060174240.htm

White Lake Public Advisory Council. 2002. White Lake Community Action Plan, Remedial Action Plan Update. 42pp.

Appendix A

Bear Creek and Bear Lake Watershed Information and Education Strategy

Appendix A
Information and Education Strategy

A-1 Introduction

The Bear Creek & Bear Lake Watershed Steering Committee was formed in spring of 2002 to identify the watershed residents concerns with respect to water quality in the Bear Creek and Bear Lake Watershed. A public survey was drafted by the Muskegon Conservation District in accordance with the MDEQ approved Quality Assurance Project Plan (QAPP), with help from the Steering Committee, and was mailed out to 520 watershed residents to assess the general public's awareness of water quality issues in the watershed. With Bear Creek & Bear Lake Watershed residents in mind, an advisory group was formed to address information and educational objectives and opportunities for effective watershed management practices.

The Bear Creek & Bear Lake Watershed Advisory Group meets, on average, once a month to discuss current and upcoming watershed activities and issues. The residents involved in the advisory group assisted in the development of this Information and Education Plan, which addresses methods to increase public awareness, interest, and participation in the watershed. In addition, the Bear Creek & Bear Lake Watershed Advisory Group will act as a bridge by creating a partnership between the residents and local governments in the watershed. This Partnership will help to increase awareness, and create communication paths between stakeholders and will ultimately provide for improved management of the watershed. The Information and Education Plan will act as a tool for educators, decision makers, and interested residents and will help to increase public awareness and involvement with historic, current, and future watershed issues. Based upon findings from the mailed survey, the I&E Plan targets specific audiences where information and education is lacking with the overall goal to improve water quality in the watershed through effective stewardship. It is to educate and inform the vast variety of people that live, work, and play within the Bear Creek & Bear Lake Watershed.

The mailing list developed by Muskegon Conservation District for the public survey will be used to target specific communities on water quality issues within the Bear Creek & Bear Lake Watershed. It is essential that all communities within the watershed be involved to achieve the project's goals.

A-2 Bear Creek & Bear Lake Watershed Advisory Committee

The Bear Creek/Bear Lake Watershed covers 19,058-acres of land and includes five local governments. The governments with jurisdiction in the watershed include City of North Muskegon; and Dalton, Muskegon, Laketon, and Cedar Creek Townships.

Mission Statement
The Bear Lake and Bear Creek Watershed Advisory Committee's mission is…*"To restore, conserve, and protect for future generations, the Bear Creek & Bear Lake Watershed as a valuable natural resource and to inspire community stewardship through awareness, education, and research."*

Bear Creek & Bear Lake Watershed Advisory Committee

* John Snider	Muskegon County Commissioner
* Dave Peden	LEPC/Muskegon Chemical Council
* Roland Crummel	Laketon Township Supervisor
* Dick Grenel	Laketon Township – Zoning Administrator
* Chris Witham	City of North Muskegon - Mayor
* Greg Mund	USDA / NRCS
* Kathy Evans	Timberland RC&D
* Tony Jarvis	Muskegon Conservation District
* Rebecca Bieneman	Muskegon Conservation District
* Steve Coverly	Muskegon Conservation District
* Jeff Auch	Muskegon Conservation District
* Tim Hall	Michigan Department of Environmental Quality
* Kyle Olsen	Senator Jerry VanWoerkom's office
* James Muston	Cedar Creek Township
* Gary and Marcia Payne	Residents
* Dr. Justin Kleaveland	Resident
* Kathleen Kleaveland	Resident
* Bob Cutler	Resident
* Cheri Hoover	Resident
* Felicia Swirczek	Resident
* John Swirczek	Resident
* Bill Naymick	Resident
* Jan Naymick	Resident
* Becky Injerd	Resident

A-3 Information and Education Objectives

1) Increase public awareness and understanding of water quality issues within the watershed, and to address the concerns identified by residents within the Bear Creek / Bear Lake Watershed.
2) Increase the public's participation, responsibility, and stewardship by encouraging participation in watershed stewardship projects.
3) Create a partnership among residents and local governments within the Bear Creek & Bear Lake Watershed to share ideas and sponsor activities to increase awareness of watershed management.

4) Encourage the City of North Muskegon and the townships of Dalton, Muskegon, Laketon, and Cedar Creek to develop communication paths and strategies to work together on watershed management practices.

A-4 Information & Education Activities

Watershed Brochures
Factual brochures and/or newsletters will be produced providing information about current watershed issues and ecologically sound watershed management practices. The brochures/newsletters will explain procedures or activities that, when performed by each individual within the Bear Creek & Bear Lake Watershed, will improve and maintain the watershed's integrity. Brochures will be sent out through the mail along with being placed at a number of businesses throughout the watershed.

Newsletters
Informational Bear Creek and Bear Lake Watershed newsletters will be distributed throughout the watershed. Events, accomplishments, problems and educational material will be included in the newsletters. Newsletters will be sent out quarterly throughout the life of the Bear Creek Watershed Project. Muskegon Conservation District Staff will prepare and distribute the newsletters.

Posters
Posters will be made of the Bear Creek & Bear Lake Watershed with a diagram showing the issues/concerns within the watershed and management practices that will correct the problem. Posters will give the residents that are not aware a chance to see the problems and get an interest in preserving Bear Creek & Bear Lake Watershed. Posters will be displayed at watershed businesses and in township offices.

Watershed Tours
Tours of the Bear Creek & Bear Lake Watershed will be given to stakeholders within the watershed to educate them about watershed management. The watershed tours will cover an array of different topics regarding watershed management practices. Topics will include stream bank erosion, bank stabilization, septic management, surface water runoff, surface and groundwater contamination, and the importance of buffer strips.

Watershed Festival
A watershed festival will be held to get the residents involved and to raise awareness of water quality issues within the Bear Creek & Bear Lake Watershed. The festival will be a combination of education, recreation, and cleanup/restoration activities. Activities could include a Bear Creek hike, identification of different types of vegetation, vegetation planting demonstration, beach cleanups, and canoe trips on Bear Lake.

Promotional Materials
Materials such as hats, bags, t-shirts, pens/pencils, mugs, etc, will be made up with the Bear Creek & Bear Lake Watershed logo on them to promote a healthy return for the

watershed. Such materials will be handed out to project volunteers to thank them for their participation and to people who are interested in the Bear Creek & Bear Lake watershed project.

Public Meetings
Meetings and presentations will be held for the residents in the Bear Creek & Bear Lake Watershed to inform and educate them on the nonpoint source pollution issues identified in the watershed management plan: 1) Excessive sedimentation; 2) Nutrients in surface and groundwater; 3) Algal blooms; 4) Contaminated sediments that end up in groundwater; and 5) Riparian buffers for wildlife habitat in the riparian zone. Presentations will address the pollutants, sources, and causes of the issues listed above.

Adopt – A – Watershed
The Adopt-A-Watershed Program will be implemented in the Bear Creek & Bear Lake Watershed to do cleanups, recruit volunteers and perform bank stabilization projects in priority areas of the watershed. The program will also promote the overall watershed projects goals and objectives, and can be organized on a sub-watershed basis.

Site Cleanups
There will be designated days throughout the year devoted to the cleanup of the Bear Creek & Bear Lake Watershed. Schools, organizations, businesses, and residents will be asked to donate their time and efforts. The Adopt-A-Watershed Program leader will oversee the arrangements for site cleanups in the Bear Creek & Bear Lake Watershed.

Storm Drain Stickering
Working with schools, community groups, and volunteers storm drain stickering will be done throughout the City of North Muskegon and the storm-sewered areas along the M-120 corridor to discourage residents from dumping pollutants down storm drains and to educate residents on the potential negative effects of stormwater runoff.

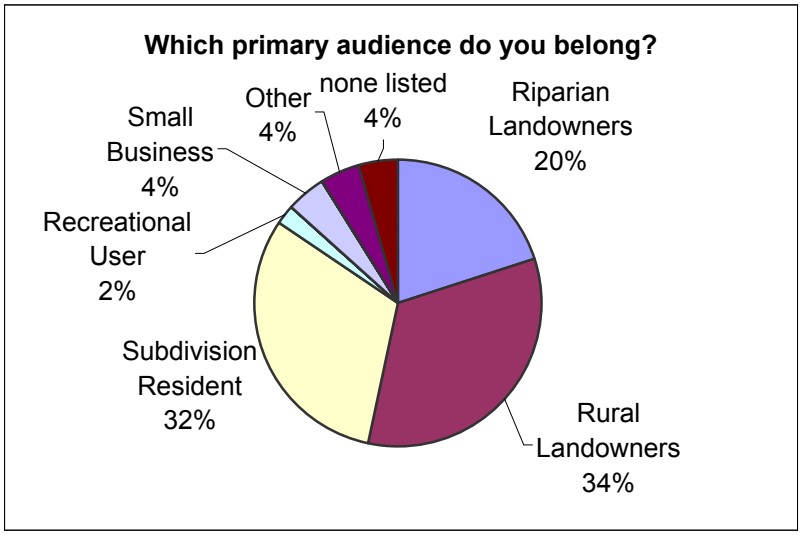
Table 1. Information and Education Activities

I&E Activities	**Quantity**	**Cost**
Watershed Brochures	2500	$2500
Newsletters	12000	$12000
Watershed Posters	50	$250
Watershed Tours	2	$1500
Watershed Festival	2	$2000
Promotional Materials	200	$2000
Public Meetings	8	$800
Adopt –A- Watershed	2	$1000
Site Cleanups	5	$2000
Storm Drain Stickering	500	$1000
Total		**$25,050**

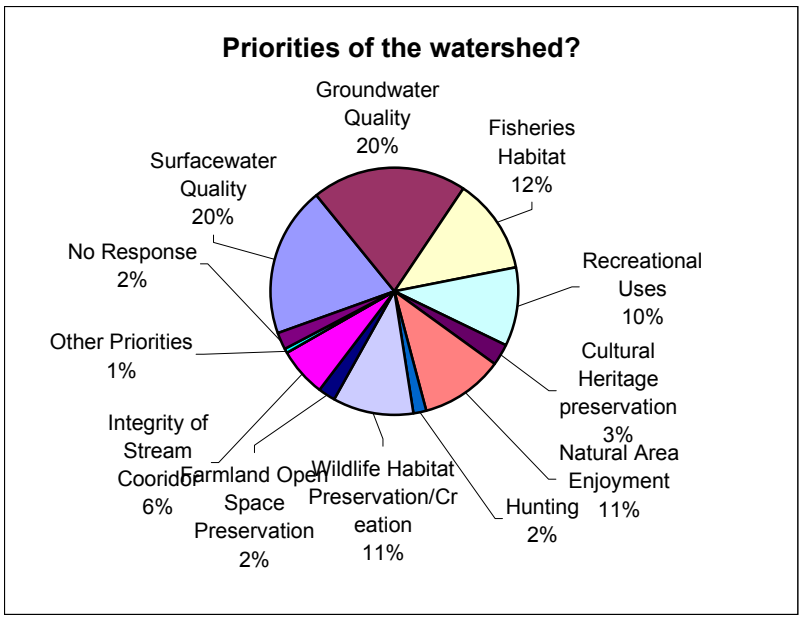
A-5 Target Audience Input / Concerns

Input on the actions needed to restore and protect the Bear Creek and Bear Lake Watershed was provided through focus group meetings and a public input surveys. This section provides a summary of the findings as well as the most effective activities to be carried out for each specific target audience.

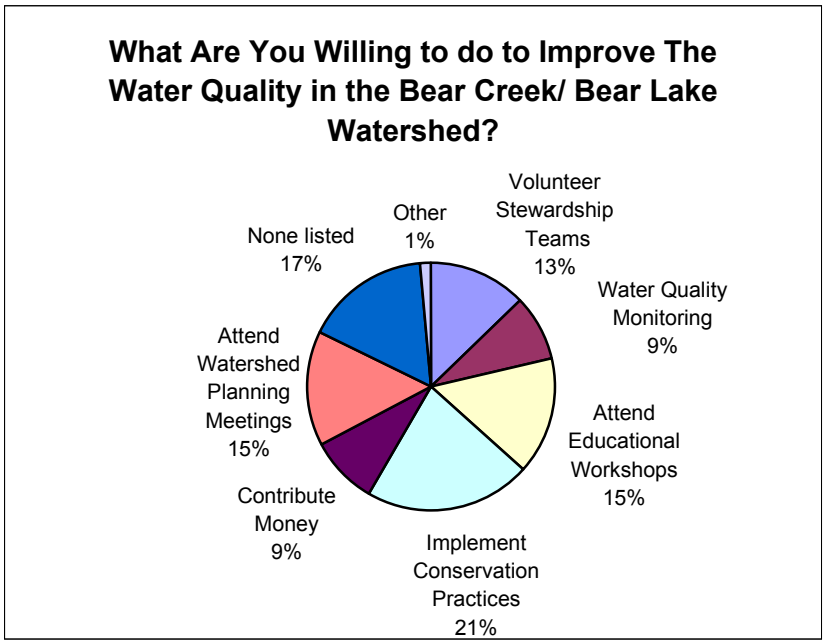
Public Input Survey Results:
There were a total of 54 responses to the Public Input Survey sent out to a sample of watershed residents. The following stakeholder groups were represented: Rural Landowners – 34%, Subdivision Residents – 32%, Riparian Landowners – 20%, Small Business – 4%, Recreational User – 2%, Other audience – 4%



Survey respondents (representing all stakeholder groups combined) ranked priority areas for watershed management in relation to the Bear Creek and Bear Lake Watershed.



The Bear Creek Public Input Survey was valuable in identifying the ways watershed residents are willing to participate to improve water quality in the watershed. This information will help guide the Bear Lake /Bear Creek Watershed Advisory Committee in their outreach and community involvement efforts.



In addition to the other categories, desired future stewardship efforts and improvements were gathered as a part of the Public Input Survey. Residents had the opportunity to express which specific improvements they would like to see in the Bear Creek and Bear Lake Watershed. They are listed in order of importance:

1. Increased natural areas for wildlife habitat and public use
2. Improve coldwater fishery
3. Improve warmwater fishery
4. Reduce sediment from stream banks
5. Land preservation
6. Reduce sediment from road/stream crossings
7. Increased recreation along Bear Creek and its tributaries
8. Manage forests for timber harvests

A-6 Focus Group Meetings:

In addition to the Public Input Survey, watershed residents and interested stakeholders participated in two separate focus group meetings during early 2002. The focus group meetings helped guide preliminary information and education activities as well as provided valuable community input regarding educational, research, and management needs. A summary of both focus group meetings is included at the end of this Appendix.

A-7 Target Audiences:

Based on the stated objectives for the I & E Strategy (listed in section A-3) for the Bear Creek and Bear Lake Watershed Management Plan, key target audiences, whose support is essential to achieve the watershed project goals, have been identified and include the following in no particular order: Local Government Officials, K-12 Educators and Students, Urban Residents, Riparian Landowners, Rural Residents, Recreational Users/Tourists, Industry/Developers/Excavators, and the Agricultural Community.

Local Government Officials

Local government officials or policy makers make day-to-day decisions that directly affect water quality. With that in mind, it is important to inform, educate and involve policy makers with watershed issues and watershed activities. The success of the Watershed Management Plan depends greatly on sound decisions being made and best management practices (BMPs) being implemented.

Concerns:

1) Awareness of the impacts their decisions make on water quality issues and activities
2) Lack of ownership of the Bear Creek & Bear Lake Watershed and apathy toward involvement in water quality issues and concerns
3) The implementation of best management practices (BMPs)

Activities:

1) Attend city, village, and township meetings to discuss best management practices (BMPs) and land use planning
2) Involved local elected officials in watershed meetings and activities
3) Integrate Bear Creek and Bear Lake Watershed Stormwater Management Plan into master plans.
4) Integrate Site Plan Review Guide with existing site plan review process for all watershed governments
5) Distribute educational packets to townships, cities, and villages
6) Workshops/presentations for local boards and planning commissions
7) Adopt floodplain, hydric souls set back regulations

K-12 Educators and Students

The students of today are future stewards and decision makers for the Bear Creek & Bear Lake Watershed. It is important for educators to have the necessary knowledge and resources to teach students about best management practices. Through awareness, our students will be able to make sound decisions in the future.

Concerns:

1) Awareness and knowledge of the Bear Creek & Bear Lake Watershed by educators and students
2) Lack of local watershed educational materials on watershed issues and water quality
3) Practice of watershed education in the curriculum of area schools

Activities:
1) Educator workshops to increase the knowledge and awareness of the Bear Creek / Bear Lake Watershed
2) Perform stream monitoring activities with students and club members
3) Fieldtrips and classroom visits to educate students on best management practices
4) Organize a club for student involvement in the Bear Creek & Bear Lake Watershed

Urban Residents

The urban community in the lower portion of the watershed is continuing to expand, which is leading to the conversion of agricultural land and open field into residential and commercial land uses. Urban communities impact water quality with activities such as fertilizer/pesticide use, septic system management, removal of shoreline/streamside vegetation, and urban/stormwater runoff.

Concerns:
1) Urban contaminants such as gas and oil being picked up by stormwater and being directly discharged into surface waters
2) Surface water to groundwater contamination
3) Lawn/garden fertilizers and pesticides entering waterways
4) Contamination from household hazardous wastes

Activities:
1) Present residents with the concerns about groundwater and surface water issues regarding stormwater management practices.
2) Inform residents of the impact fertilizers/pesticides will have in the Bear Creek & Bear Lake watershed ecosystems.
3) Provide residents with dates that household hazardous wastes can be properly disposed of.
4) Inform and educate residents of the loss of wildlife corridors, resulting from traditional urban development
5) Work with businesses to install rain gardens/infiltration basins to effectively manage stormwater runoff

Riparian Landowners

Waterfront property owners within the Bear Creek & Bear Lake watershed can have a major impact on the quality of water. Nonpoint source pollution such as failing septic systems, sedimentation, and nutrient loadings from poorly timed fertilizer applications are the some of the major causes of degraded water quality. Waterfront property is very fragile and it needs to be managed to reduce the impacts of nonpoint source pollution. Native vegetative buffers between manicured lawns and waterways trap excess nutrients, sediment, and other pollutants from entering the water.

Concerns:
1) Lawn/garden fertilizers and pesticides entering waterways
2) Nutrients from compost piles and septic systems
3) Contamination from household hazardous waste

4) Residents and recreational users introducing exotic species into the watershed
5) The use of watercraft that increases shoreline erosion and allows chemicals such as oil and gas to enter the waterway
6) Removal of native vegetative buffer
7) Loss of wildlife corridor due to habitat fragmentation

Activities:
1) Use the Conservation District programs and staff to plan, design, and assist with installation of ecologically sensitive stormwater management practices, yard and garden management, soil testing, drinking water well management, and septic system maintenance.
2) Use meetings to inform riparian landowners on the status of the watershed project and ways they can help move the project forward.
3) Use newsletter articles and newspaper articles to inform residents regarding lake activities and waterfront practices.
4) Use brochures to keep riparian landowners aware of specific best management practices (BMPs).
5) Empower watershed residents to make educated decisions on lake management by informing them of both the positive and negative ecological effects of chemical treatment of nuisance aquatic plants.
6) Inform and educate residents of the loss of wildlife corridors, resulting from traditional residential development/fragmentation.

Rural Residents

The majority of the central and upper watershed residents in the Bear Creek & Bear Lake watershed are considered rural landowners. Rural communities are being faced with new challenges concerning urban sprawl and development. Rural communities affect water quality with septic system use, the use of pesticides/fertilizers, and potential runoff of pollutants. The way rural landowners use their land has marked effects on fish and wildlife habitat as well as water quality.

Concerns:
1) Lawn/garden fertilizers and pesticides entering waterways
2) Contamination from household hazardous waste
3) Runoff of nutrients from failing septic systems
4) Removal of native vegetation
5) Loss of wildlife corridor due to habitat fragmentation

Activities:
1) Inform residents through the use of newsletters, brochures, and newspapers about watershed activities and the benefits of planting native vegetation for wildlife habitat, erosion control, and buffer practices.
2) Use the conservation district programs to present residents with stormwater management practices, yard and garden management, drinking water well management, and septic system maintenance.

3) Use watershed tours to educate residents on best management practices (BMPs) for water quality.
4) Provide residents with dates of hazardous waste and tire drop off/cleanup days.
5) Inform and educate residents of the loss of wildlife corridors, resulting from traditional residential development/fragmentation.
6) Encourage ecologically sound forest management, nutrient management through workshops, and outreach activities.

Recreational Users / Tourists

The Bear Creek & Bear Lake watershed provides the public with opportunities to hunt, view wildlife, boat, fish, canoe, and swim, among other things. Activities such as these can have a negative impact on the water quality in the Bear Creek & Bear Lake Watershed unless precautions are taken to prevent those impacts.

Concerns:
1) Erosion of shoreline and stream banks from watercraft activity and foot traffic on banks
2) Boats/tourists act as a vector to transfer nonnative species such as zebra muscles from watershed to watershed
3) Lack of awareness of watershed and water quality issues

Activities:
1) Have informational signs at watershed boundaries and local parks.
2) Place informational brochures at rest areas and other points of interest concerning impacts that boating has on watersheds with ideas on how to make it less harmful.
3) Have plastic bags present at local sporting good stores/recreational outfitters to promote keeping the watershed clean along with informational brochures concerning invasive species and watershed best management practices (BMPs).

Industry/Developers/Excavators/Commercial

Although currently there is not a lot of industry within the Bear Creek & Bear Lake Watershed, it is likely that the region will see industrial growth in the near future. The industries in the Bear Creek & Bear Lake Watershed impact water quality by having industrial accidents/spills and industrial discharges into the environment. Developers and Excavators also impact water quality with sedimentation and nutrient loadings within the watershed. Increased stormwater runoff volumes from impervious surfaces in these areas are also a threat to water quality in that they will increase turbidity and sedimentation in Bear Creek and Bear Lake.

Concerns:
1) Sediment deposition from construction sites and the building on banks that are unstable
2) Hazardous waste spills
3) The release of fertilizers and pesticides by developers/excavators
4) The illicit discharge from industrial developments
5) Removal of valuable vegetation during construction/excavation

Activities:

1) Develop relationships with industries/developers/excavators to make them aware of problems caused by erosion, fertilizer/pesticide use, and hazardous chemicals spills.
2) Seek sponsorship for local events to increase awareness.
3) Use newsletters and brochures to keep residents aware of the benefits of using buffer strips, construction site management techniques, and overall watershed best management practices (BMPs).

Agricultural Community

The agricultural community in the Bear Creek & Bear Lake Watershed makes up approximately 6% of the land use. Both the historic and current agricultural practices have had an impact on water quality within the watershed. Although current amounts of agriculture in the watershed are relatively small, the drainage ditches dug to lower the water table in order to make the land suitable for historic agriculture/development, pose a remaining risk. Sediments and nutrients may enter the Bear Creek and Bear Lake watershed at these exposed ditches. These pollutants are typical in agricultural areas and can contribute to the degradation of Bear Creek as well as Bear Lake.

Concerns:

1) Cropland erosion of sediments and nutrients
2) Contamination from crop protection materials
3) Surface/Ground water quality
4) Nutrients and fecal coliform from livestock access to streams
5) Loss of integrity of the stream corridor
6) Thermal pollution degrading fisheries

Activities:

1) Develop educational tools and demonstration sites to show best management practices in the watershed.
2) Utilize conservation district programs to review things such as septic system maintenance, pesticide/fertilizer storage and handling, management of drinking water, etc.
3) Hold a groundwater stewardship tour to educate residents on the relationships between surface water and groundwater.
4) Promote clean sweep programs, recycling programs, and hazardous waste drop off events through newsletters, brochures and newspaper articles.

Table 2. Information and Education Activities Schedule - Bear Creek and Bear Lake Watershed Management Plan

I&E Activities	Quantity	Cost	Total Hours	Cost w/Staffing	Implementation
Watershed Brochures	2500	$2500	40	$3,300	July 2004
Newsletters	12000	$12000	320	$18,400	June 2004 – June 2006
Watershed Posters	50	$250	30	$850	January 2005
Watershed Tours	2	$1500	40	$2,300	September 2004, 2005
Watershed Festival	2	$2000	150	$5,000	August 2004, 2005
Promotional Materials	200	$2000	75	$3,500	June 2004-June 2006
Public Meetings	8	$800	160	$4,000	June 2004-June 2006
Adopt –A- Watershed	2	$1000	100	$3,000	June 2004, June 2005
Site Cleanups	5	$2000	200	$6,000	June 2004 - June 2006
Storm Drain Stickering	500	$1000	80	$2,600	June 2004 - October 2006
Total		**$25,050**		**$48,950**	

MEETING SUMMARY

Bear Creek and Bear Lake Watershed
Focus Group Meeting # 1

Hosted by Muskegon Conservation District
March 6, 2002
7:00 – 9:00 p.m.
Dalton Township Fire Station

Participants: See Attached Meeting Attendance list for names of participants.

Meeting Summary:
Twenty (20) attendees were presented with an overview of the Bear Creek & Bear Lake Watershed Plan. The presenters were Kathy Evans, Muskegon Conservation District (MCD) Water Quality Program Manager, John Reinders, MCD- Michigan Groundwater Stewardship Program AmeriCorps Volunteer, and Greg Mund, U.S. Department of Agriculture- Natural Resource Conservation Service (USDA-NRCS), Resource Conservationist.

Following the presentations, Kathy Evans and Rebecca Parker, MCD Water Quality Project Specialist, facilitated a public input process. Participants were asked to express what they valued about the Bear Creek/Bear Lake watershed; what they felt was important to protect and restore; and what issues and concerns they had.

Following the brainstorming session, participants were asked to "rank the importance of the action items" that were identified during a "fishbone process". Each participant was given 6 "sticky dots" or votes and asked to either use them all on one action or use them on individual action items. The results are listed below.

Values and Concerns

1. Erosion along stream banks- Riley Thompson and Beattie Roads.
   -Ribe drain
2. Need for recycle stations for:
   -Used motor oil
   -Used anti-freeze
   -Household hazardous wastes
3. Illegal trash dumping (old sites) – junk/salvage yards
   -Staple Road
4. Sewage dumping near McMillan and Central
   -Septic hauler
5. Recreation on Lake and Creek
   -Boating, canoeing, hunting, fishing, and trapping
6. 500-acre zone at Ott/Story/Cordova
   -Buildings and pavement
   -Need to be mindful of the potential for disturbance of polluted areas and non-point source concerns
7. Sewer system = Rapid growth along Whitehall Road = more people = more difficult to address the watershed issues in a timely manner.
8. Cost of Townships rise with the rapid development
   -Rapid Growth = more runoff and erosion
9. Need to identify storage capacity areas for storm water in the watershed
10. Coordination of zoning ordinances between local governments, continuity between townships
11. Maintaining suitable wildlife habitats (*mentioned two times)*
    -Buffers where necessary

12. Sediment build-up in culverts (pipes) at Bard Rd. and Beattie Rd.
13. Surface water / runoff into Bear Creek
    -Dump south of McMillan, west of Pillon top of hill on left
    -Part of a cement block building/ bulldozer
14. Exotics- zebra mussels in water system and purple loosestrife
15. Same controls across boundaries for nuisance species
16. Are there any more pollution sites?
17. Twin Lake home density\septic tanks
18. Fishing- lack of fish species that were once in the area, last saw trout and steelhead in Bear Creek in the '70's. Salmon were seen in the fall of 2001 below McMillan Road.
19. The 1977 flood was in basement at Bard and Beattie Roads
    -Culverts are half full of sediment
20. Fishing (trout habitat)
21. Land Use Planning *(mentioned two times)*
22. Flooding in general along Bear Creek
23. Students need to be involved in monitoring and working with the environment
    -Trained on different aspects so that they can participate
24. Activities affecting groundwater
    -Superfund Site-Duell Gardner
25. Drinking/well water at River Road and M-120
26. Cost share funds for "landowners" to grow cover crops
27. Beach issues-
    -Swimmers itch in Bear lake N. Muskegon/ Laketon Township
28. Residential use of phosphorous fertilizers that effect the lake
29. Zebra mussels in the lake
30. Address Bear Lake residential practices that effect the water quality of Bear Lake
31. Storm water outfalls need detention
    -North Muskegon and a couple small ones in Laketon Township
32. Twin Lake Storm water outfalls too
33. Monitor Ott/Story/Cordova ground water system and biology of the stream
34. Planning commission coordinate on undeveloped land
35. US-31 – 2 big tubes (culverts) and Chase Hammond flood potentials
36. Floating vegetation on Bear Creek at Riley Thompson and Beattie Roads
    -Slowing water flow rate
37. Commercial development along M-120 and River Road
    -Water quality impacts and lack of wildlife habitat
38. Bridge washout McMillan and Putnum Roads - '77
39. Wide difference of North Muskegon residents on how to address "weeds"
    -Need careful balancing
40. Maintain trees and forested land around the stream
41. Preservation of open space for quality of life and to avoid fragmentation of forest benefits
42. Timber and wildlife habitats and opportunities for agricultural production
43. Identify groundwater recharge areas for floodplain and wetland preservation
44. Identify sensitive areas
45. Drain Twin Lake – gravity drain to Bear Creek
46. 29' well on Staple Road, concerned about water table lowering and needing to drill a deeper well and the effects of lake to be constructed at Nugent Sands on the quality of ground/well water.

Summary of Concerns:
Focus group concerns varied slightly covering five topics. These topics are Natural Resources, Recreation, Education, Land Use Planning and Regulatory Management.

The concerns related directly to Bear Creek included:
General resident concern about the erosion of banks along the creek in the Riley Thompson and Beattie Road area, lack of ability to recreate on Bear Creek, runoff of surface water into Bear Creek.

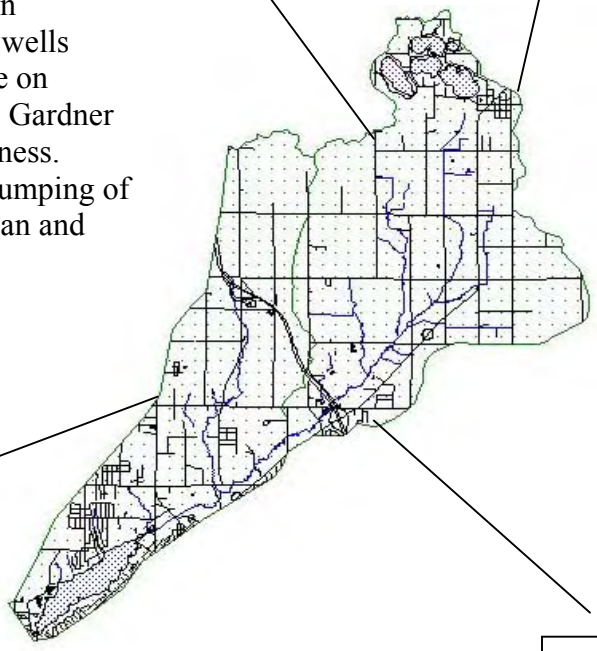
Bear Creek /Bear Lake March 6, 2002
Focus Group Meeting Results
(Number corresponds with number of votes)

Regulatory; 24

-Clean up old dumps
-Underground leaking tanks, Orchard Foods area
-Citizens committee to track polluted site clean up/progress.
-Identify all polluted sites known & unknown
-Including old oil wells
-EPA/DEQ update on Ott/Story & Duell Gardner clean up effectiveness.
-Address illegal dumping of sewage at McMillan and Central.

Natural Resource Management; 20

-Promote and expand recycling of oil and hazardous waste
-Infiltration
-Address sediment/erosion through BMP's and preservations of vegetation in riparian areas.
-Flood Management
-Address sand removal/lake creation and potential pollution issues
-Retention/detention of storm water runoff.



Land Use Planning; 23

-Muskegon Area Plan (MAP) will coordinate with all local units
-Identification of sensitive areas
-Master Plans need to address best places to develop and preserve
-Need to update ordinances, like Dalton Twp; Laketon Twp. is in progress.

Education; 26

-Marina/Boat/Exotics Management
-K-12
-Adults
-Land Use
-Fertilizer application

MEETING SUMMARY

Bear Creek and Bear Lake Watershed
Focus Group Meeting # 2
Hosted by Muskegon Conservation District
April 11, 2002
7:00 – 9:00 p.m.
North Muskegon Public Schools
High School Cafeteria

Participants: See Attached Meeting Attendance list for names of participants.

Meeting Summary:
Thirteen (13) attendees were presented with an overview of the Bear Creek & Bear Lake Watershed Plan. The presenters were Kathy Evans, Muskegon Conservation District (MCD) Water Quality Program Manager, John Reinders, MCD- Michigan Groundwater Stewardship Program AmeriCorps Volunteer, and Greg Mund, U.S. Department of Agriculture- Natural Resource Conservation Service (USDA-NRCS), Resource Conservationist.

Following the presentations, Kathy Evans and Rebecca Parker, MCD Water Quality Project Specialist, facilitated a public input process. Participants were asked to express what they valued about the Bear Creek/Bear Lake watershed; what they felt was important to protect and restore; and what issues and concerns they had.

Following the brainstorming session, participants were asked to "rank the importance of the action items" that were identified during the process. Each participant was given 6 "sticky dots" or votes and asked to either use them all on one action or use them on individual action items. The results are listed below.

Values and Concerns
1. East end with prevailing wind westerly wind= sea weed/ algae drift resulting in organic settling there
2. There's not a lot of flow in the lake, naturally occurring.
3. Ott/ Story drainage.
4. More research needed on the lake bottom/sediment.
5. Analysis of Water Quality in Bear Lake= 6-18" of foam along shore in the last two years from N/W bear Lake Road to Ruddiman.
6. More deer around lake edge with lower lake levels
7. Need short, precise mailings: A,B,C's of lake management → fact sheet
8. Need to advertise, "campaign" about fertilizer/lake management, options and alternatives
    a. Let people know where to get "no phosphorus" fertilizers
9. Fenners Ditch algal bloom → three years ago
10. Management of Chicago River and it's effect on lake level's
11. Fewer frog's and turtles (over the last ten years); virtually no water snakes for twenty years, rubber backs, snappers, mountain backs, still see box and painted turtles
12. Need engines manufactured for boat and jet ski's that are cleaner for the environment
13. There may be a need for a Lake Board to form

14. Clean up the sides of the creek 9old pipes, outlets from old septic tanks, garbage, metal scrap, etc.)
15. 2-cycle recreation boat engines contribute pollution to the lakes
16. Windy days results in more boats on Bear lake (recreational water craft off of Muskegon Lake) = pollution and litter concerns
17. Blue-green algal blooms start at end of June used to start end of
18. "Amounts" of lawn fertilizer and lawn care companies (phosphorus fertilizer) contribute to phosphorus levels
19. Eagles, owls seen spring 2002, ospreys and herons and 2 loons
20. Shallow habitat is decreasing with lower lake levels
21. Purple loosestrife impact on cattails (etc.) need more education on control methods
22. Talk to municipalities about:
    a. Road salt amounts are too high/overkill – okay on Ruddiman; not necessary on back roads
    b. Don't even need salt, snow plowing works well in North Muskegon
23. Get municipalities involved in planning and education for the watershed
24. Residents are trying to "make a dent" with their practices on property – need local government to do the same on the larger scale
25. The bottom/benthos of Bear Lake is rotted organic matter and it picks up runoff/oil = lack of recreational opportunities, turbidity
26. Nice habitat with sand, and clay bottom too (10 % sand)
27. Perch habitat
28. Oil drilling occurred and wells were capped- what happened to the oil? Fenner's Ditch
29. Andree Rd. improperly abandoned (oil field closure)
30. Engineering Dimension found oil near Andree Rd. with soil borings
31. Need help with exotic species and native species management Phosphorus fertilizer/ weed spraying/ education help lake association and provide recreation opportunities
32. Lake levels/buffer establishment issues
33. Laketon Township sewer – When?
    a. Pumping station near Wilbrandts
34. Whitehall main is coming (but not close by)
35. Bear Lake old septic tanks on North side and abandoned on city side
36. Property transfers require inspection – on north side on-site septic
37. Clay Shield on North side 10-12' deep comes to 5-6" of soil surface
38. A buffer along the lake and streams with vegetation to filter runoff and nutrients
39. Need a map to show where the septic, sewer, and old failing septic areas of the watershed

Action Items

The numeral, following each action item, indicates the number of votes to indicate the relative importance of the identified action.

1. Create short precise mailings to give the ABC's of Lake management → Fact sheet – 14
2. Talk to municipalities about:
    1. Use of too much road salt
    2. Use of salt okay on Ruddiman; not necessary on back roads - 13
3. More research is needed on Lake bottom and sediments. – 12
4. Advertise or "campaign" about fertilizer/lake management options and alternatives – 11

5. Analysis of water Quality in Bear Lake = 6-18” of foam along shore in last two years from North-west Bear Lake Road to Ruddiman. – 9
6. Oil wells have been closed – what happened to the oil?
    1. Fenner’s Ditch (Andree Rd. have been improperly abandoned) - 7
7. Form a Lake Board – 4
8. Create a map to show where the septic tank, sewered homes, and old failing septic areas of the watershed. - 4
9. Clean up the sides of Bear Creek (old pipes, outlets from old septics, garbage, metal scrap, etc.) – 3
10. Property transfers require inspection (on north side) for on site septic – 1
11. Talk to engine manufacturer’s about boat and jet ski engines – 0
12. Lake levels/buffer establishment issues – 0

Develop a buffer along the lake and streams with vegetation to filter runoff and nutrients – 0

Public Input Survey:

Bear Creek/ Bear Lake Watershed 319 Project
Information and Education Needs Assessment Survey

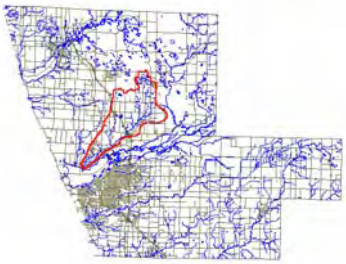
The purpose of this survey is to assess awareness and the education and information needs of individuals in the Bear Creek/Lake Watershed. This information will be used to document the natural resource priorities and concerns of watershed residents, and to tailor technical and educational programs to meet identified needs.

1. In what township or city do you reside and/or work?_____

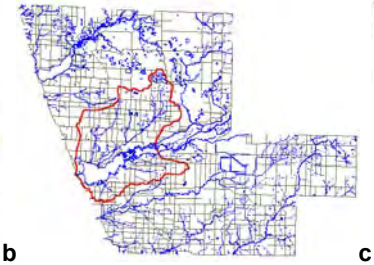
2. Which watershed are you within? (check all that apply)
___Bear Creek ___Bear Lake ___Twin Lake(s) ___Muskegon Lake ___Lake Michigan

3. Which of the following boundaries defines the Bear Creek and Bear Lake Watershed?
Circle one

a



b



c

4. To which <u>primary</u> (1) and <u>secondary</u> (2) (if applicable) audience do you belong?

___ Riparian Landowners ___ Agriculture/Livestock Producer ___ Construction Industries
___ Rural Landowner ___ Hobby Farm/Horse Ranch ___ Industry
___ Subdivision resident ___ Local Decision Makers ___ Educator/Teacher
___ Recreational Users ___ Small Business ___ Students (K-12)
___ Other(s), please name: _____ ___ None

5. To which specific affiliation do you belong (i.e.: Trout Unlimited, Twin Lake School, etc.)?
_____

6a. How do you use Bear Creek?

___ Wading ___ Swimming ___ Wildlife Watching ___ Fishing ___ Tubing
___ Hunting ___ Irrigation ___ Pasturing ___ Canoeing ___Education
___ Other (list): _____ ___ Not used

6b. How do you use Bear Lake?

___ Wading ___ Swimming ___ Wildlife Watching ___ Fishing ___Tubing
___ Boating ___ Hunting ___ Irrigation ___ Canoeing ___ Education
___ Other (list): _____ ___ Not used

7. Please number (1,2,3,4,5) your priorities, if any, regarding the Bear Creek/Lake watershed: 1-high to 5-low

___ Surface Water Quality ___ Natural Area Enjoyment ___ Integrity of stream corridor
___ Ground Water Quality ___ Hunting ___ I have nothing to prioritize
___ Fisheries Habitat ___ Wildlife Habitat Preservation/Creation
___ Recreational Uses ___ Farmland/Open Space Preservation
___ Cultural Heritage Preservation ___ Other: _____

8. What improvements would you like to see in the Bear Creek/Lake watershed? Please number (1-5).

___ Improved cold-water fishery ___ Natural areas for wildlife habitat and public use
___ Improved warm water fishery ___ Locally produced/marketed food
___ Land preservation ___ Increased recreation along river and tributaries
___ Reduced sedimentation at eroding road-stream crossings
___ Reduced sedimentation from eroding stream banks
___ Manage Forest for timber harvest ___ Other (List): _____

9. What value do trees and shrubs provide along the riparian corridor of the Bear Creek Watershed?

___ Soil stabilization
___ Decrease thermal pollution
___ Habitat for wildlife
___ Add nutrients to the water body
___ No value

10. The best place to wash your vehicle is?

___ Lawn or field
___ Carwash Facility
___ Driveway or street side
___ Unsure

11. Disposing of chemical waste at the curbside or in the storm drain is okay and does not affect water quality.

___ True ___ False ___ Unsure

12. A "buffer strip" beside a body of water includes trees, shrubs, and grasses. This helps to protect the water body from pollutants such as: (check all that apply)

___ Soil, sediment
___ Sunlight, heat
___ Fertilizer, nutrients
___ Lawn clippings
___ Heated water runoff
___ Pet waste
___ None listed

13. What are you willing to do to improve the water quality in the Bear Creek/Lake Watershed? *(We may contact you concerning your answers to this question if you provide contact information below.)*

___ Attend Bear Creek/Lake Watershed Planning Meetings
___ Contribute Money to Muskegon Conservation District to "match" future Bear Creek Watershed Grants
___ Volunteer on Stewardship Teams (i.e.: "River Day" stream bank cleanups, habitat improvement projects, volunteer monitoring, etc.)
___ Implement Conservation Practices on your land (erosion control, wildlife habitat improvement, reforestation projects)
___ Water Quality Monitoring
___ Attend Educational Workshops on Conservation Practices for Water Quality
___ Other: _____

Contact Information (Confidential)

Your contact information is necessary for the evaluation process of this survey.

Name: _____
Address: _____
City: _____ State: _____ Zip: _____
Phone: _ E-mail: ___
Fax: _____

Return by mail or fax to: Muskegon Conservation District

1001 E. Wesley Ave., Rm. 6, Muskegon, MI 49442, Phone: (231) 773-0008 Fax: (231) 773-1210

___ I would like to receive regular mailings. My conservation-related areas of interest are:
_____

___ I would like you to call/contact me about: __

___ I would like information about volunteer/stewardship trainings and opportunities.

___ Please contact me for Technical/Planning and/or Educational Assistance.

Return by mail or fax to:
Muskegon Conservation District
1001 E. Wesley Rm. 6
Muskegon, MI 49442

Phone: (231) 773-0008 Fax: (231) 773-1210

Appendix B

Bear Creek and Bear Lake Watershed Stream Inventory

Bear Creek Watershed

Stream Bank Inventory
&
Road-Stream Crossing Survey

prepared by the Muskegon Conservation District
February 2004

Bear Creek Watershed

Stream Bank Inventory
&
Road-Stream Crossing Survey

Survey Procedures

All surveyors were field trained in the proper procedure for the collection of data. The stream bank inventory was conducted by walking the creek, whereas the road / stream crossings were identified both on foot and driven to. The location of each site was mapped using a Garmin GPS system and ArcView GIS. Color photographs were taken for most sites, especially those with severe problems. This document will continue to be updated and pictures added as sites are revisited.

All road stream crossing surveys were conducted according to MDEQ's "Stream Crossing Watershed Survey Inventory" and utilizing a modified worksheet. The survey is intended to be utilized as a quick screening inventory to increase the amount of information available on the water quality of a river, identify issues and the need for more in depth investigation (Fig. 1). Stream bank erosion surveys were conducted according to USDA protocol and ranked utilizing scoring criteria for each site (Fig. 2). The site rankings were determined by scoring the field data sheets according to the site severity rating/index combined with field judgment by surveyors.

Total repair costs were calculated for each site utilizing appropriate equations for the following Best Management Practices (BMPs) and the associated materials.

- Grade stabilization structures
- Grassed waterways
- Critical area planting in gullied areas
- Water and sediment control basins
- Fencing livestock out of a stream
- Bank stabilization using vegetation
- Bank stabilization using armoring
- Shoreline stabilization
- Crop, pastureland, and construction sites to control sheet and rill erosion
- Buffer and filter strips

In general, the equation is:
Total savings per year (tons) = length X height of eroded bank X lateral recession rate X dry density soil weight.

Stream Bank Site Ratings
Severe / High Priority: 3 sites (#3, #17, #23)
Moderate: 17 sites
Minor: 13 sites

Road-Stream Crossing Priority Ranking
High Priority / Poor Culvert Rank: 5 crossings (BC2, LB2, BLD2, BD2, BD3)
Medium: 12 crossings
Low: 33 crossings
Not Evaluated: 1 crossing

The following individuals were trained and participated in the collection of data:
Tony Jarvis
Rebecca Bieneman
Kathy Evans
Greg Mund
Steve Coverly

Bear Creek Watershed
Volunteer Water Quality Monitoring

Date:_____ Time:_____ Investigator:_____

SITE INFORMATION

County / Township:
Section: _____T _____R _____ 1/4 _____ 1/4
Waterbody Name:
Location:
Station #:
Road Name:

Latitude _____ **N**, *Longitude* _____ **W**
Coordinate determination method (check one that applies):
_____GPS
_____GPS w/DBR
_____Digital mapping software
_____Topographic map
*(map scale if known)*_____
_____Other (Describe:_____)

ROAD CROSSING INFORMATION

Type of road crossing	_____bridge _____single culvert _____twin culvert _____other(_____)
Type of road surface	_____paved _____cement _____ gravel _____sand
Land ownership	_____private _____state _____federal _____other (_____)
Road Maintenance	_____seasonal _____all year
Drainage control features	_____none _____present & functional _____need repair (_____)
Length of approach	_____ (ft.) left side *if looking downstream* _____right side (ft.)
Slope of approach	*Left side:* _____0% _____1-5% _____6-10% _____>10%
	Right side: _____0% _____1-5% _____6-10% _____>10%
Culvert Description	_____(ft.) length _____ (ft.) diameter
Culvert Condition	_____good _____fair _____poor
Culvert Flow Capacity	_____obstructed _____unobstructed
Fill Above Culvert	_____(ft.) Upstream end _____(ft.) Downstream end
Width of crossing directly above stream	_____ft.
Average width of grade, including shoulders/ditches	_____ft.
Location of the low point	_____at stream _____other (_____)

BACKGROUND INFORMATION

Event conditions noted at site	_____None _____Light _____Moderate _____Heavy
ays since rain	_____ 1 or less _____2 _____3 _____Unknown
Temperature	_____
Dissolved Oxygen	_____
PH	_____
Water Color	_____clear _____ gray _____brown _____black _____green
Waterbody Type – upstream	_____stream _____ lake _____ impounded _____wetland
Waterbody Type – downstream	_____stream _____ lake _____ impounded _____wetland
Stream width (ft.)	_____<10 _____10-25 _____25-50 _____>50
Average stream depth (ft.)	_____<1 _____1-3 _____>3 _____unknown
Water velocity (ft./sec.)	_____
Stream flow type	_____dry _____stagnant _____low _____medium _____high
Bank slopes	_____vertical _____1:1 _____1.5:1 _____2:1 _____>2:1

PHYSICAL APPEARANCE

Aquatic Plants	*Upstream*: _____Present _____Abundant	*Downstream*: _____Present _____Abundant
Floating Algae	*Upstream*: _____Present _____Abundant	*Downstream*: _____Present _____Abundant
Filamentous Algae	*Upstream*: _____Present _____Abundant	*Downstream*: _____Present _____Abundant
Bacterial Sheen / Slimes	*Upstream*: _____Present _____Abundant	*Downstream*: _____Present _____Abundant
Turbidity	*Upstream*: _____Present _____Abundant	*Downstream*: _____Present _____Abundant
Oil Sheen	*Upstream*: _____Present _____Abundant	*Downstream*: _____Present _____Abundant
Foam	*Upstream*: _____Present _____Abundant	*Downstream*: _____Present _____Abundant
Trash	*Upstream*: _____Present _____Abundant	*Downstream*: _____Present _____Abundant

INSTREAM COVER

Check all that apply for each site

Undercut banks	*Upstream*: _____	*Downstream*: _____
Overhanging vegetation	*Upstream*: _____	*Downstream*: _____
Deep Pools	*Upstream*: _____	*Downstream*: _____
oulders	*Upstream*: _____	*Downstream*: _____
quatic Plants	*Upstream*: _____	*Downstream*: _____
Logs or Woody Debris	*Upstream*: _____	*Downstream*: _____

Figure 1. Road-stream crossing inventory data sheet (page 1 of 3)

SUBSTRATE

% for each upstream and downstream site should add up to 100%

Boulder – 10 in. diameter	*Upstream*: _____% of total	*Downstream*: _____% of total
Cobble / Gravel		
10 - .08 in. diameter	*Upstream*: _____% of total	*Downstream*: _____% of total
Sand – coarse grain	*Upstream*: _____% of total	*Downstream*: _____% of total
Silt / detritus / Muck		
Fine grain, organic matter	*Upstream*: _____% of total	*Downstream*: _____% of total
Hardpan / bedrock		
Solid clay, rock surface	*Upstream*: _____% of total	*Downstream*: _____% of total
Artificial – manmade	*Upstream*: _____% of total	*Downstream*: _____% of total
Unknown	*Upstream*: _____% of total	*Downstream*: _____% of total

RIVER MORPHOLOGY

Riffle	*Upstream*: _____ present _____ abundant	*Downstream*: _____ present _____abundant
Pool	*Upstream*: _____ present _____ abundant	*Downstream*: _____ present _____abundant
Channel	*Upstream*: _____ natural _____recovering _____ maintained	
	Downstream: _____ natural _____recovering _____maintained	
Designated Drain	*Upstream*: _____unknown _____yes _____ no	
	Downstream: _____unknown _____yes _____no	
Highest water mark (ft.)	_____unknown _____<1 _____1-3 _____3-5 _____5-10 _____>10	

STREAM CROSS SECTION

Draw a cross section of the site that best depicts the characteristics of the site

STREAM CORRIDOR

Riparian vegetation width (ft.)	
Left bank, facing downstream	*Upstream*: _____<10 _____10-30 _____30-100 _____>100
	Downstream: _____<10 _____10-30 _____30-100 _____>100
Riparian vegetation width (ft.)	
Right bank, facing downstream	*Upstream*: _____<10 _____10-30 _____30-100 _____>100
	Downstream: _____<10 _____10-30 _____30-100 _____>100
Bank erosion	
	Upstream: _____none _____low _____medium _____high
	Downstream: _____none _____low _____medium _____high
Streamside land cover	
	Upstream: _____bare _____ground cover _____shrubs _____trees
	Downstream: _____bare _____ground cover _____shrubs _____trees
Stream canopy %	
	Upstream: _____<25 _____25-50 _____>50
	Downstream: _____<25 _____25-50 _____>50

ADJACENT LAND USES

Wetlands	*Upstream*: _____left side _____right side	*Downstream*: _____left side _____right side
Shrub or old field	*Upstream*: _____left side _____right side	*Downstream*: _____left side _____right side
Forest	*Upstream*: _____left side _____right side	*Downstream*: _____left side _____right side
Pasture	*Upstream*: _____left side _____right side	*Downstream*: _____left side _____right side
Crop residue	*Upstream*: _____left side _____right side	*Downstream*: _____left side _____right side
Row crop	*Upstream*: _____left side _____right side	*Downstream*: _____left side _____right side
Residential lawns, parks	*Upstream*: _____left side _____right side	*Downstream*: _____left side _____right side
Impervious surfaces	*Upstream*: _____left side _____right side	*Downstream*: _____left side _____right side
Disturbed ground	*Upstream*: _____left side _____right side	*Downstream*: _____left side _____right side
No vegetation	*Upstream*: _____left side _____right side	*Downstream*: _____left side _____right side

Figure 1. Road-stream crossing inventory data sheet (page 2 of 3)

POTENTIAL SOURCE SEVERITY

***S**-slight, **M**-Moderate, **H**-High*

Crop related sources	*Upstream*: _____S _____M _____H	*Downstream*: _____S _____M _____H
Grazing related sources	*Upstream*: _____S _____M _____H	*Downstream*: _____S _____M _____H
Intensive animal feeding	*Upstream*: _____S _____M _____H	*Downstream*: _____S _____M _____H
Highway/Road/Bridge *Maintenance and runoff*	*Upstream*: _____S _____M _____H	*Downstream*: _____S _____M _____H
Channelization	*Upstream*: _____S _____M _____H	*Downstream*: _____S _____M _____H
Dredging	*Upstream*: _____S _____M _____H	*Downstream*: _____S _____M _____H
Removal of riparian vegetation	*Upstream*: _____S _____M _____H	*Downstream*: _____S _____M _____H
Band and shoreline erosion *Modification/destruction*	*Upstream*: _____S _____M _____H	*Downstream*: _____S _____M _____H
Flow regulation / Modification	*Upstream*: _____S _____M _____H	*Downstream*: _____S _____M _____H
Upstream impoundment	*Upstream*: _____S _____M _____H	*Downstream*: _____S _____M _____H
Construction: *Highway/road/bridge/culvert*	*Upstream*: _____S _____M _____H	*Downstream*: _____S _____M _____H
Construction: *Land development*	*Upstream*: _____S _____M _____H	*Downstream*: _____S _____M _____H
Urban Runoff	*Upstream*: _____S _____M _____H	*Downstream*: _____S _____M _____H
Land disposal	*Upstream*: _____S _____M _____H	*Downstream*: _____S _____M _____H
On-site wastewater systems	*Upstream*: _____S _____M _____H	*Downstream*: _____S _____M _____H
Silviculture	*Upstream*: _____S _____M _____H	*Downstream*: _____S _____M _____H
Resource extraction, mining	*Upstream*: _____S _____M _____H	*Downstream*: _____S _____M _____H
Recreational, Tourism activities	*Upstream*: _____S _____M _____H	*Downstream*: _____S _____M _____H
Golf courses	*Upstream*: _____S _____M _____H	*Downstream*: _____S _____M _____H
Marinas, Recreational boating *Water releases*	*Upstream*: _____S _____M _____H	*Downstream*: _____S _____M _____H
Marinas, Recreational boating *Bank & shoreline erosion*	*Upstream*: _____S _____M _____H	*Downstream*: _____S _____M _____H
Debris in water	*Upstream*: _____S _____M _____H	*Downstream*: _____S _____M _____H
Industrial point source	*Upstream*: _____S _____M _____H	*Downstream*: _____S _____M _____H
Municipal point source	*Upstream*: _____S _____M _____H	*Downstream*: _____S _____M _____H
Natural sources	*Upstream*: _____S _____M _____H	*Downstream*: _____S _____M _____H
Source(s) unknown	*Upstream*: _____S _____M _____H	*Downstream*: _____S _____M _____H

SITE SUMMARY INFORMATION

Survey direction	_____not applicable _____upstream _____downstream
Site similarity	_____unknown _____ yes _____no
Overall site ranking	_____low _____medium _____high
Overall crossing/culvert rank	_____good _____bad _____ requires immediate attention
Site follow-up rank	_____low _____medium _____high

SITE DESCRIPTION COMMENTS

SITE PHOTOS

Upstream: _____film #, _____frames *Downstream*: _____film #, _____frames

Figure 1. Road-stream crossing inventory data sheet (page 3 of 3)

Bear Creek / Bear Lake Watershed

Stream Severity Rating/Index

Total Points = Site Severity Index/Rating

More than 36	*Severe*
30 to 36	*Moderate*
Less than 30	*Minor*

Condition of Bank:
(5) Toe and Upper Bank Eroding
(3) Toe Undercutting
(1) Toe Stable, Upper Bank Eroding

Problem Trend:
(5) Increasing
(1) Decreasing or Stable

Apparent Cause of Erosion:
(5) Heavy Access Use
(3a) Moderate Access Use
(3b) Road-Stream Crossing/Grade/Shoulder Run-Off
(2) Bend in River
(1a) Light Access Use
(1b) Bank Seepage
(1c) Gullying by Side Channels
(1d) Obstruction in River

Mean Height of Eroded Bank:
(7) Greater than 20 Feet
(5) 10 Feet to 20 Feet
(3) 5 Feet to 10 Feet
(1) Less than 5 Feet

Current Speed:
(2) Fast
(1) Slow

Vegetative Cover on Bank Slope
(5) 0% to 10%
(3) 10% to 50%
(1) Greater than 50%

Side Slope of Bank:
(5) Vertical 1:1
(3) 2:1, 3:1 (~ 45%)
(1) 4:1 or Flatter

Length of Eroding Bank:
(5) Greater than 50 Feet
(3) 20 Feet to 50 Feet
(1) Less than 20 Feet

Depth (at Toe of Slope):
(2) Greater than 3 Feet
(1) 3 Feet or Less

Soil Type and Texture:
(3) Sand
(2a) Gravel
(2b) Stratified
(1) Clay, Loam

Comments:

Figure 2. Streambank Erosion Inventory – site ranking sheet

STREAMBANK INVENTORY

Site 1

County:	Muskegon
GPS:	N43°16.395 - W86°15.002
Priority Ranking:	**NOT EVALUATED**
Site Length:	
Bank Height:	
Water Depth	
Slope:	
Soil Type:	sand
Vegetation Cover:	
Problem:	Discharge
Cause:	Unknown
Loss / Year (tons):	
BMP:	
Total Repair Costs:	
Comments/Notes:	*Orange colored discharge from small side tributary*

Site 1

Site 2

County:	Muskegon
GPS:	N43°16.395 - W86°15.002
Priority Ranking:	**(30) MODERATE**
Site Length:	60
Bank Height:	3.5
Water Depth	1
Slope:	45° or more
Soil Type:	sand
Vegetation Cover:	10% - 50%
Problem:	Toe and upper bank eroding
Cause:	Bend in river
Loss / Year (tons):	1.50
BMP:	Streambank Stabilization
Total Repair Costs:	$1,550
Comments/Notes:	*Provide vegetation for stabilization. Opposite banks also experiencing erosion at high water*

Site 2

Site 3

	2 projects/locations at site
County:	Muskegon
GPS:	N43°16.410 - W86°14.962
Priority Ranking:	**(36) SEVERE, (26) MINOR**
Site Length:	90
Bank Height:	5 (average)
Water Depth	1
Slope:	45° or more
Soil Type:	sand
Vegetation Cover:	0% - 10%
Problem:	Toe and upper bank eroding
Cause:	Bend in river, heavy access use
Loss / Year (tons):	2.41
BMP:	Streambank Stabilization
Total Repair Costs:	$1,400
Comments/Notes:	*Deer crossing and bend in river combining to destabilize bank*

Site 3

Site 4

County:	Muskegon
GPS:	N43°16.530 - W86°14.573
Priority Ranking:	**(35) MODERATE**
Site Length:	60
Bank Height:	3
Water Depth	1
Slope:	more than 45°, nearer 90°
Soil Type:	sand
Vegetation Cover:	0% - 10%
Problem:	Toe and upper bank eroding
Cause:	Bend in river
Loss / Year (tons):	1.29
BMP:	Streambank Stabilization
Total Repair Costs:	$1,350
Comments/Notes:	*Cistern near RR crossing*

Site 4

Site 5

County:	Muskegon
GPS:	N43°16.568 - W86°94.395
Priority Ranking:	**(33) MODERATE**
Site Length:	150
Bank Height:	50
Water Depth	2
Slope:	45° or more
Soil Type:	sand
Vegetation Cover:	10% - 50%
Problem:	Toe and upper bank eroding
Cause:	Bend in river, bank seepage
Loss / Year (tons):	53.63
BMP:	Streambank Stabilization
Total Repair Costs:	$3,250
Comments/Notes:	

Site 5

Site 6

	2 projects/locations at site
County:	Muskegon
GPS:	N43°16.719 - W86°14.350
Priority Ranking:	**(30, 31) MODERATE**
Site Length:	80 (two projects at site)
Bank Height:	7 (average)
Water Depth	1
Slope:	more than 45°, close to 90°
Soil Type:	sand
Vegetation Cover:	10% - 50%
Problem:	Toe undercutting
Cause:	Bend in river
Loss / Year (tons):	4.08
BMP:	Streambank Stabilization
Total Repair Costs:	$4,542
Comments/Notes:	

Site 6

Site 7

County:	Muskegon
GPS:	N43°16.878 - W86°13.994
Priority Ranking:	**(26) MINOR**
Site Length:	30
Bank Height:	3
Water Depth	1
Slope:	45° or more
Soil Type:	sand
Vegetation Cover:	greater than 50%
Problem:	Toe and upper bank eroding
Cause:	Bend in river
Loss / Year (tons):	0.15
BMP:	Streambank Stabilization
Total Repair Costs:	$3,048
Comments/Notes:	

Site 7

Site 8

County:	Muskegon
GPS:	N43°17.177 - W86°13.595
Priority Ranking:	**(21) MINOR**
Site Length:	7
Bank Height:	5
Water Depth	1
Slope:	45° or greater
Soil Type:	sand
Vegetation Cover:	0% - 10%
Problem:	Toe stable, upper bank eroding
Cause:	Gullying by side channels
Loss / Year (tons):	0.06
BMP:	Grade Stabilization Structure
Total Repair Costs:	$1,900
Comments/Notes:	*Rock chute on south side of creek – old drainage ditch*

Site 8

Site 9

County:	Muskegon
GPS:	N43°17.205 - W86°13.559
Priority Ranking:	**(29) MINOR**
Site Length:	100
Bank Height:	6
Water Depth	1
Slope:	45° or greater
Soil Type:	sand
Vegetation Cover:	10% - 50%
Problem:	Toe undercutting
Cause:	Bend in river
Loss / Year (tons):	0.99
BMP:	Streambank Stabilization
Total Repair Costs:	$1,200
Comments/Notes:	*Use of Brush bundles tied and small log revetments, 12-15" thick.*

Site 9

Site 10

County:	Muskegon
GPS:	N43°17.247 - W86°13.509
Priority Ranking:	**(27) MINOR**
Site Length:	120
Bank Height:	4
Water Depth	1
Slope:	45° or greater
Soil Type:	sand
Vegetation Cover:	10% - 50%
Problem:	Toe undercutting
Cause:	Bend in river
Loss / Year (tons):	0.79
Total Repair Costs:	$45,935
Comments/Notes:	*Rock chute west of horse barn, drainage ditch outlet, north. side of stream. Horse crossing.*

Site 10

Site 11

County:	Muskegon
GPS:	N43°17.349 - W86°13.387
Priority Ranking:	**(29) MINOR**
Site Length:	140 (2 sites)
Bank Height:	5
Water Depth	1
Slope:	45° or greater
Soil Type:	sand
Vegetation Cover:	10% - 50%
Problem:	Toe and upper bank eroding
Cause:	Bend in river
Loss / Year (tons):	1.52
BMP:	Streambank Stabilization
Total Repair Costs:	$4,588
Comments/Notes:	*Includes north and south side. Gas line crosses creek – 100% exposed. Pack stone at toe.*

Site 11

Site 12

County:	Muskegon
GPS:	N43°17.406 - W86°13.130
Priority Ranking:	**(30) MODERATE**
Site Length:	70
Bank Height:	8
Water Depth	1
Slope:	45° or greater
Soil Type:	stratified
Vegetation Cover:	10% - 50%
Problem:	Toe and upper bank eroding
Cause:	Bend in river
Loss / Year (tons):	4.00
BMP:	Streambank Stabilization
Total Repair Costs:	$3,034
Comments/Notes:	*Utilize filter cloth and pack rock into toe area to 2' above water level.*

Site 12

Site 13

County:	Muskegon
GPS:	N43°17.417 - W86°12.980
Priority Ranking:	**(21) MINOR**
Site Length:	100
Bank Height:	3
Water Depth	1
Slope:	45° or greater
Soil Type:	sand, clay, loam
Vegetation Cover:	10% - 50%
Problem:	Toe undercutting
Cause:	Bend in river
Loss / Year (tons):	0.5
BMP:	Streambank Stabilization
Total Repair Costs:	$2,998
Comments/Notes:	*40' bank above stream*

Site 13

Site 14

County:	Muskegon
GPS:	N43°17.642 - W86°12.753
Priority Ranking:	**(31) MODERATE**
Site Length:	330 (4 projects at site)
Bank Height:	6.5
Water Depth	1
Slope:	45° or greater
Soil Type:	sand
Vegetation Cover:	10% - 50%
Problem:	Toe and upper bank eroding
Cause:	Bend in river
Loss / Year (tons):	15.67
BMP:	Streambank Stabilization
Total Repair Costs:	$14,702
Comments/Notes:	*Site includes four sites in same proximity. Stone and filter cloth needed, including using brush bundles tree revetments and willow staking*

Site 14

Site 15

County:	Muskegon
GPS:	N43°17.676 - W86°12.673
Priority Ranking:	**(32) MODERATE**
Site Length:	340 (3 projects at site)
Bank Height:	6 (average)
Water Depth	1
Slope:	more than 45°, nearer 90°
Soil Type:	sand
Vegetation Cover:	10% - 50%
Problem:	Toe and upper bank eroding
Cause:	Moderate access use (foot trail and two-track access)
Loss / Year (tons):	10.02
BMP:	Streambank Stabilization
Total Repair Costs:	$13,062
Comments/Notes:	*a) Pond outlet rusting away and washing side bank, needs to be replaced; b) Brush bundles and shrub staking. Remove larger trees to redirect flow; c) Rock and cloth slope near paved bridge crossing.*

Site 15

Site 16

County:	Muskegon
GPS:	N43°17.684 - W86°12.661
Priority Ranking:	**(32) MODERATE**
Site Length:	80
Bank Height:	4
Water Depth	2
Slope:	more than 45°, nearer 90°
Soil Type:	sand
Vegetation Cover:	0% - 10%
Problem:	Toe undercutting
Cause:	Obstruction in river
Loss / Year (tons):	2.29
BMP:	Streambank Stabilization
Total Repair Costs:	$4,164
Comments/Notes:	*Brush bundles, filter cloth, and shrub / plugs needed at site*

Site 16

Site 17

County:	Muskegon
GPS:	N43°17.716 - W86°16.647
Priority Ranking:	**(38) SEVERE**
Site Length:	1600 (both bank sides)
Bank Height:	4
Water Depth	1
Slope:	45° to vertical
Soil Type:	sand
Vegetation Cover:	10% - 50%
Problem:	*Toe and upper bank eroding*
Cause:	Gullying by side channels, grade, shoulder run-off, bank seepage
Loss / Year (tons):	70.40
BMP:	Streambank Stabilization
Total Repair Costs:	$46,058
Comments/Notes:	*Downstream of culvert within inside of highway right-of-way*

Site 17

Site 18

County:	Muskegon
GPS:	N43°17.855 - W86°12.492
Priority Ranking:	**(29) MINOR**
Site Length:	50
Bank Height:	8
Water Depth	1
Slope:	45° or greater
Soil Type:	stratified
Vegetation Cover:	10% - 50%
Problem:	Toe and upper bank eroding
Cause:	Bend in river
Loss / Year (tons):	1.77
BMP:	Streambank Stabilization
Total Repair Costs:	$3,940
Comments/Notes:	*Downstream from a golf course with a pond equalizer tube. Bush bundles and plugs in bank for stabilization needed.*

Site 18

Site 19

County:	Muskegon
GPS:	N43°17.882 - W86°12.390
Priority Ranking:	**(28) MINOR**
Site Length:	70
Bank Height:	4
Water Depth	18
Slope:	45° or greater
Soil Type:	stratified, sand
Vegetation Cover:	10% - 50%
Problem:	Toe undercutting
Cause:	Obstruction in river
Loss / Year (tons):	0.46
BMP:	Streambank Stabilization
Total Repair Costs:	$2,400
Comments/Notes:	*Brush bundles, filter cloth, and shrub / plugs needed at site*

Site 19

Site 20

County:	Muskegon
GPS:	N43°18.779 - W86°11.460
Priority Ranking:	**(30) MODERATE**
Site Length:	30
Bank Height:	10
Water Depth	1
Slope:	45° or more
Soil Type:	sand
Vegetation Cover:	0% to 10%
Problem:	Toe stable, upper bank eroding
Cause:	Bend in river
Loss / Year (tons):	2.15
BMP:	Streambank Stabilization
Total Repair Costs:	$400
Comments/Notes:	*Stabilize bank with filter cloth and vegetative ground cover to avoid top slope sliding.*

Site 20

Site 21

County:	Muskegon
GPS:	N43°18.816 - W86°11.444
Priority Ranking:	**(32) MODERATE**
Site Length:	20
Bank Height:	10
Water Depth	1
Slope:	45° or more
Soil Type:	sand
Vegetation Cover:	10% - 50%
Problem:	Toe and upper bank eroding
Cause:	Bend in river
Loss / Year (tons):	1.43
BMP:	Streambank Stabilization
Total Repair Costs:	$450
Comments/Notes:	*Coconut bundles for undercutting and river bend with vegetative stakes for bank.*

Site 21

Site 22

County:	Muskegon
GPS:	N43° - W86°
Priority Ranking:	**(32) MODERATE**
Site Length:	1200 (both banks)
Bank Height:	3
Water Depth	1
Slope:	more than 45°, close to 90°
Soil Type:	sand
Vegetation Cover:	0% to 10%
Problem:	Toe and upper bank eroding
Cause:	Bend in river
Loss / Year (tons):	25.74
BMP:	Grade Stabilization Structure (2)
Total Repair Costs:	$7,590
Comments/Notes:	*Check dams at Riley – Thompson (W. Michigan Equestrian Center) north of creek juncture.*

Site 22

Site 23

County:	Muskegon
GPS:	N43°18.315 - W86°12.154
Priority Ranking:	**(36) SEVERE**
Site Length:	30
Bank Height:	20
Water Depth	1
Slope:	more than 45°, close to 90°
Soil Type:	sand
Vegetation Cover:	0% to 10%
Problem:	Toe stable, upper bank eroding
Cause:	Bank seepage, gullying and side channels, road-stream crossing, grade, shoulder run-off
Loss / Year (tons):	9.90
BMP:	Grade Stabilization Structure
Total Repair Costs:	$8,275
Comments/Notes:	*Chase-Hammond Golf Course drain contributing large amount of sediment and major source of erosion.*

Site 23

Site 24

County:	Muskegon
GPS:	N43°18.598 - W86°12.108
Priority Ranking:	**(31) MODERATE**
Site Length:	35
Bank Height:	20
Water Depth	1
Slope:	45° or more
Soil Type:	sand
Vegetation Cover:	10% - 50%
Problem:	Toe and upper bank eroding
Cause:	Bend in river
Loss / Year (tons):	5.01
BMP:	Streambank Stabilization *and* Grade Stabilization Structure
Total Repair Costs:	$2,405
Comments/Notes:	*Upper bank erosion from pipe draining into stream. Undercutting occurring and need brush bundles and/or coconut logs.*

Site 24

Site 25

County:	Muskegon
GPS:	N43°18.629 - W86°12.076
Priority Ranking:	**(34) MODERATE**
Site Length:	40
Bank Height:	20
Water Depth	1
Slope:	45° or more
Soil Type:	sand
Vegetation Cover:	10% - 50%
Problem:	Toe and upper bank eroding
Cause:	Bend in river
Loss / Year (tons):	5.72
BMP:	Streambank Stabilization
Total Repair Costs:	$2,925
Comments/Notes:	*Minimal vegetative cover. Shrub stakes needed to stabilize ban and brush bundles or coconut logs for undercutting.*

Site 25

Site 26

County:	Muskegon
GPS:	N43°18.862 - W86°12.128
Priority Ranking:	**(33) MODERATE**
Site Length:	30
Bank Height:	25
Water Depth	1
Slope:	more than 45°, close to 90°
Soil Type:	sand
Vegetation Cover:	0% to 10%
Problem:	Toe and upper bank eroding
Cause:	Bend in river
Loss / Year (tons):	5.36
BMP:	Streambank Stabilization
Total Repair Costs:	$950
Comments/Notes:	*Vegetative stakes needed to stabilize ban and brush bundles or coconut logs for undercutting. Slope is moss covered with some tree growth*

Site 26

Site 27

County:	Muskegon
GPS:	N43°18.953 - W86°12.180
Priority Ranking:	**(31) MODERATE**
Site Length:	20
Bank Height:	20
Water Depth	1
Slope:	45° or more
Soil Type:	sand
Vegetation Cover:	10% to 50%
Problem:	Toe and upper bank eroding
Cause:	Bend in river
Loss / Year (tons):	2.86
BMP:	Streambank Stabilization
Total Repair Costs:	$750
Comments/Notes:	*Significant amount of undercutting. Upper bank eroding and need vegetation to stabilize. Undercut area requires brush bundles and /or coconut rolls pushed under bank.*

Site 27

Site 28

County:	Muskegon
GPS:	N43°17.504 - W86°14.765
Priority Ranking:	**(27) MINOR**
Site Length:	40
Bank Height:	15
Water Depth	.5
Slope:	45° or more
Soil Type:	sand
Vegetation Cover:	10% - 50%
Problem:	Toe and upper bank eroding
Cause:	Bend in river
Loss / Year (tons):	0.99
BMP:	Streambank Stabilization
Total Repair Costs:	$950
Comments/Notes:	

Site 28

Site 29

County:	Muskegon
GPS:	N43°17.903 - W86°14.188
Priority Ranking:	**(28) MINOR**
Site Length:	45
Bank Height:	30
Water Depth	1
Slope:	45° or more
Soil Type:	sand
Vegetation Cover:	greater than 50%
Problem:	Toe stable, upper bank eroding
Cause:	Bend in river
Loss / Year (tons):	2.23
BMP:	Streambank Stabilization
Total Repair Costs:	$910
Comments/Notes:	*Upper bank eroding at access point. Vegetation needed with coconut brush bundles*

Site 29

Site 30

County:	Muskegon
GPS:	N43°17.943 - W86°14.208
Priority Ranking:	**(34) MODERATE**
Site Length:	45
Bank Height:	15
Water Depth	1
Slope:	45° or more
Soil Type:	sand
Vegetation Cover:	10% - 50%
Problem:	Toe and upper bank eroding
Cause:	Bend in river
Loss / Year (tons):	4.83
BMP:	Streambank Stabilization
Total Repair Costs:	$910
Comments/Notes:	*Brush bundles and coconut rolls needed with shrub stakes and groundcover.*

Site 30

Site 31

County:	Muskegon
GPS:	N43°18.392 - W86°14.185
Priority Ranking:	**(27) MINOR**
Site Length:	100
Bank Height:	3.5
Water Depth	1
Slope:	45° or more
Soil Type:	sand
Vegetation Cover:	10% - 50%
Problem:	Toe undercutting
Cause:	Bank seepage
Loss / Year (tons):	0.58
BMP:	Streambank Stabilization
Total Repair Costs:	$2,021
Comments/Notes:	*Near private drive crossing. Needs vegetation and filter strip. Minor erosion at crossing*

Site 31

Site 32

County:	Muskegon
GPS:	N43°18.425 - W86°14.173
Priority Ranking:	**(28) MINOR**
Site Length:	40
Bank Height:	3.5
Water Depth	1
Slope:	45° or more
Soil Type:	sand
Vegetation Cover:	0% to 10%
Problem:	Toe undercutting
Cause:	Bend in river
Loss / Year (tons):	0.23
BMP:	Streambank Stabilization
Total Repair Costs:	$809
Comments/Notes:	

Site 32

Site 33

County:	South of Tyler Rd. Muskegon
GPS:	N43° - W86°
Priority Ranking:	**(30) MODERATE**
Site Length:	1100 (both banks)
Bank Height:	1.5
Water Depth	1
Slope:	more than 45°, close to 90°
Soil Type:	sand
Vegetation Cover:	10% to 50%
Problem:	Toe and upper bank eroding
Cause:	Bend in river
Loss / Year (tons):	11.80
BMP:	Grade Stabilization Structure (2)
Total Repair Costs:	$7,590
Comments/Notes:	*Downstream of Tyler Rd. Check dams and sediment basin*

Site 33

Road – Stream Inventory

Site BC1

County:	Muskegon
Waterbody:	Bear Creek
Road Crossing:	Whitham
GPS:	N43°15.954 - W86°15.698
Priority Ranking:	**LOW**
Culvert Ranking:	Good
Site Length:	
Bank Height:	
Soil:	sands, loamy sand
Recession Rate:	
Loss / Year (tons):	
BMP:	
Total Repair Costs:	
Comments/Notes:	

BC1

Site BC2

	2 locations / projects at site
County:	Muskegon
Waterbody:	Bear Creek
Road Crossing:	Whitehall Rd.
GPS:	N43°16.208 - W86°15.335
Priority Ranking:	**HIGH**
Culvert Ranking:	Good
Site Length:	162
Bank Height:	11 (average)
Soil:	sand, silt
Recession Rate:	0.4
BMP:	Grade Stabilization Structure Streambank Stabilization Structure
Loss / Year (tons):	44.9
Total Repair Costs:	$2,950
Comments/Notes:	*Rock chute at outlet, ditch reshaping, and Critical Area Planting*

BC2

Site BC3

County:	Muskegon
Waterbody:	Bear Creek
Road Crossing:	Russell Rd.
GPS:	N43°16.494 - W86°14.610
Priority Ranking:	**LOW**
Culvert Ranking:	Good
Site Length:	
Bank Height:	
Soil:	Sands, loamy sand
Recession Rate:	
Loss / Year (tons):	
BMP:	
Total Repair Costs:	
Comments/Notes:	

BC3

Site BC4

County: Muskegon
Waterbody: Bear Creek
Road Crossing: Railroad Crossing
GPS: N43° - W86°
Priority Ranking: **LOW**
Culvert Ranking: Good
Site Length:
Bank Height:
Soil: Sands, loamy sand
Recession Rate:
Loss / Year (tons):
BMP:
Total Repair Costs:
Comments/Notes:

BC4

Site BC5

County: Muskegon
Waterbody: Bear Creek
Road Crossing: Giles
GPS: N43°16.679 - W86°14.385
Priority Ranking: **LOW**
Culvert Ranking: Good
Site Length:
Bank Height:
Soil: Sands, loamy sand
Recession Rate:
Loss / Year (tons):
BMP:
Total Repair Costs:
Comments/Notes:

BC5

Site BC6

County: Muskegon
Waterbody: Bear Creek
Road Crossing: Engman Rd.
GPS: N43° - W86°
Priority Ranking: **LOW**
Culvert Ranking: Good
Site Length:
Bank Height:
Soil: Sands, loamy sand
Recession Rate: 0.03
Loss / Year (tons):
Total Repair Costs:

Comments/Notes:

BC6

Site BC7

County:	Muskegon
Waterbody:	Bear Creek
Road Crossing:	Getty
GPS:	N43°16.935 - W86°13.974
Priority Ranking:	**MEDIUM**
Culvert Ranking	Good
Site Length:	2
Bank Height:	2
Soil:	sands, loamy sand
Recession Rate:	0.13
Loss / Year (tons):	0.03
Total Repair Costs:	$1,060
Comments/Notes:	*Rock chute*

BC7

Site BC8

County:	Muskegon
Waterbody:	Bear Creek
Road Crossing:	East Roberts
GPS:	N43°17.555 - W86°12.874
Priority Ranking:	**LOW**
Culvert Ranking	Good
Site Length:	1
Bank Height:	50
Soil:	sands, loamy sand
Recession Rate:	0.03
Loss / Year (tons):	0.08
BMP:	Grade Stabilization Structure
Total Repair Costs:	$2,645
Comments/Notes:	*Vegetative chute*

BC8

Site BC9

2 locations / projects at site

County:	Muskegon
Waterbody:	Bear Creek
Road Crossing:	US 31 (WEST SIDE)
GPS:	N43°17.555 - W86°12.874
Priority Ranking:	**MEDIUM**
Culvert Ranking	Good
Site Length:	180
Bank Height:	12 (average)
Soil:	sands, loamy sand
Recession Rate:	0.13
Loss / Year (tons):	9.72
BMP:	Streambank Stabilization Structure Grade Stabilization Structure
Total Repair Costs:	$11,548
Comments/Notes:	*Stilling basin, exit ramp; Vegetative chute, side slopes above culvert*

BC9

Site BC10

County:	Muskegon
Waterbody:	Bear Creek (EAST SIDE)
Road Crossing:	US 31 (EAST SIDE) & Putnam
GPS:	N43°17.827 - W86°12.591
Priority Ranking:	**MEDIUM**
Culvert Ranking	Good
Site Length:	80
Bank Height:	4
Soil:	sands, loamy sand
Recession Rate:	0.13
Loss / Year (tons):	2.29
BMP:	Streambank Stabilization Structure
Total Repair Costs:	$4,978
Comments/Notes:	*Stilling basin between northbound lanes*

BC10

Site BC11

County:	Muskegon
Waterbody:	Bear Creek
Road Crossing:	McMillan
GPS:	N43° - W86°
Priority Ranking:	**LOW**
Culvert Ranking	Good
Site Length:	
Bank Height:	
Soil:	Sands, loamy sand
Recession Rate:	
Loss / Year (tons):	
BMP:	
Total Repair Costs:	
Comments/Notes:	

BC11

Site BC12

County:	Muskegon
Waterbody:	Bear Creek
Road Crossing:	Pillon Rd.
GPS:	N43° - W86°
Priority Ranking:	**LOW**
Culvert Ranking	Good
Site Length:	
Bank Height:	
Soil:	Sands, loamy sand
Recession Rate:	
Loss / Year (tons):	
BMP:	
Total Repair Costs:	
Comments/Notes:	

BC12

Site LB1

County:	Muskegon
Waterbody:	Little Bear Creek
Road Crossing:	Giles
GPS:	N43°16.681 - W86°14.669
Priority Ranking:	**LOW**
Culvert Ranking	Good
Site Length:	
Bank Height:	
Soil:	Sands, loamy sand
Recession Rate:	
Loss / Year (tons):	
BMP:	
Total Repair Costs:	
Comments/Notes:	

LB1

Site LB2

County:	Muskegon
Waterbody:	Little Bear Creek
Road Crossing:	Railroad Crossing
GPS:	N43°17.408 - W86°14.837
Priority Ranking:	**HIGH (IMMEDIATE ATTENTION!)**
Culvert Ranking	Very Poor
Site Length:	60
Bank Height:	15
Soil:	sands, loamy sand
Recession Rate:	0.4
Loss / Year (tons):	19.80
BMP:	Inlet Protection
Total Repair Costs:	$5,964
Comments/Notes:	*Inlet protection, streambank stabilization. Culvert is at capacity with approx. 6" clearance. ¾ of pipe is filled with sand and possible collapse at high water or may flood areas upstream due to acting like dam.*

LB2

Site LB3

County:	Muskegon
Waterbody:	Little Bear Creek
Road Crossing:	River Rd.
GPS:	N43°17.751 - W86°14.703
Priority Ranking:	**MEDIUM**
Culvert Ranking	Good
Site Length:	7
Bank Height:	25
Soil:	sands, loamy sand
Recession Rate:	0.13
Loss / Year (tons):	1.25
BMP:	Streambank Stabilization Structure
Total Repair Costs:	$2,404
Comments/Notes:	*Rock and fill, west side of head wall*

LB3

Site LB4

3 locations / projects at site

County:	Muskegon
Waterbody:	Little Bear Creek
Road Crossing:	Russell Rd. (South)
GPS:	N43°17.812 - W86°14.501
Priority Ranking:	**LOW**
Culvert Ranking	Good
Site Length:	25
Bank Height:	30
Soil:	sands, loamy sand
Recession Rate:	0.03
Loss / Year (tons):	1.24
BMP:	Grade Stabilization Structure
Total Repair Costs:	$5,135
Comments/Notes:	*Vegetative chutes: at fire hydrant, side of Russell Rd., stream crossing on west side.*

LB4

Site LB5

County:	Muskegon
Waterbody:	Little Bear Creek
Road Crossing:	Railroad Crossing (near McMillan)
GPS:	N43° - W86°
Priority Ranking:	***NOT EVALUATED***
Culvert Ranking	
Site Length:	
Bank Height:	
Soil:	sands, loamy sand
Recession Rate:	
Loss / Year (tons):	
BMP:	
Total Repair Costs:	
Comments/Notes:	

LB5

Site LB6

County:	Muskegon
Waterbody:	Little Bear Creek
Road Crossing:	Russell Rd. (North)
GPS:	N43°18.873 - W86°14.196
Priority Ranking:	**LOW**
Culvert Ranking	Good
Site Length:	
Bank Height:	
Soil:	sands, loamy sand
Recession Rate:	
Loss / Year (tons):	
BMP:	
Total Repair Costs:	
Comments/Notes:	

LB6

Site LB7

County:	Muskegon
Waterbody:	Little Bear Creek
Road Crossing:	Tyler Rd.
GPS:	N43°19.048 - W86°14.276
Priority Ranking:	**MEDIUM**
Culvert Ranking	Good
Site Length:	60
Bank Height:	2
Soil:	sands, loamy sand
Recession Rate:	0.13
Loss / Year (tons):	0.86
BMP:	Streambank Stabilization Structure
Total Repair Costs:	$3,610
Comments/Notes:	*Stilling basin and (sediment basin – not cost shared).*

LB7

Site LB8

County:	Muskegon
Waterbody:	Little Bear Creek
Road Crossing:	Bard Rd. (Private Drive)
GPS:	N43°19.263 - W86°14.354
Priority Ranking:	**LOW**
Culvert Ranking	Good
Site Length:	
Bank Height:	
Soil:	sands, loamy sand
Recession Rate:	
Loss / Year (tons):	
BMP:	
Total Repair Costs:	
Comments/Notes:	

LB8

Site LB9

County:	Muskegon
Waterbody:	Little Bear Creek
Road Crossing:	Bard Rd.
GPS:	N43°19.317 - W86°14.366
Priority Ranking:	**LOW**
Culvert Ranking	Good
Site Length:	
Bank Height:	
Soil:	sands, loamy sand
Recession Rate:	
Loss / Year (tons):	
BMP:	
Total Repair Costs:	
Comments/Notes:	

LB9

Site LB10

County:	Muskegon
Waterbody:	Little Bear Creek
Road Crossing:	US 31
GPS:	N43°19.359 - W86°14.321
Priority Ranking:	**LOW**
Culvert Ranking	Good
Site Length:	
Bank Height:	
Soil:	sands, loamy sand
Recession Rate:	
Loss / Year (tons):	
BMP:	
Total Repair Costs:	
Comments/Notes:	

LB10

Site BLD1

County:	Muskegon
Waterbody:	Bear Lake Direct
Road Crossing:	Dykstra Rd.
GPS:	N43°16.236 - W86°15.786
Priority Ranking:	**LOW**
Culvert Ranking	Good
Site Length:	
Bank Height:	
Soil:	sands, loamy sand
Recession Rate:	
Loss / Year (tons):	
BMP:	
Total Repair Costs:	
Comments/Notes:	

BLD1

Site BLD2

County:	Muskegon
Waterbody:	Bear Lake Direct
Road Crossing:	Giles
GPS:	N43°16.635 - W86°16.150
Priority Ranking:	**HIGH**
Culvert Ranking	Good
Site Length:	40
Bank Height:	40
Soil:	sands, loamy sand
Recession Rate:	0.4
Loss / Year (tons):	35.2
BMP:	Streambank Stabilization Structure
Total Repair Costs:	$4,315
Comments/Notes:	*Stilling basin at outlet*

BLD2

Site PB1

County:	Muskegon
Waterbody:	Putnam-Bard
Road Crossing:	McMillan Rd.
GPS:	N43° - W86°
Priority Ranking:	**LOW**
Culvert Ranking	Good
Site Length:	
Bank Height:	
Soil:	sands, loamy sand
Recession Rate:	
Loss / Year (tons):	
BMP:	
Total Repair Costs:	
Comments/Notes:	

PB1

Site PB2

County:	Muskegon
Waterbody:	Putnam-Bard
Road Crossing:	Bard Rd.
GPS:	N43°19.446 - W86°12.275
Priority Ranking:	**MEDIUM**
Culvert Ranking	Good
Site Length:	40
Bank Height:	2
Soil:	sands, loamy sand
Recession Rate:	0.13
Loss / Year (tons):	0.57
BMP:	Streambank Stabilization Structure
Total Repair Costs:	$1,855
Comments/Notes:	*Rock chute, inlet protection*

PB2

Site PS1

County:	Muskegon
Waterbody:	Pillon-Staple
Road Crossing:	Bard Rd.
GPS:	N43° - W86°
Priority Ranking:	**LOW**
Culvert Ranking	Good
Site Length:	
Bank Height:	
Soil:	sands, loamy sand
Recession Rate:	
Loss / Year (tons):	
BMP:	
Total Repair Costs:	
Comments/Notes:	

PS1

Site PS2

County:	Muskegon
Waterbody:	Pillon-Staple
Road Crossing:	Pillon Rd. (south)
GPS:	N43°19.869 - W86°11.243
Priority Ranking:	**LOW**
Culvert Ranking	Good
Site Length:	
Bank Height:	
Soil:	sands, loamy sand
Recession Rate:	
Loss / Year (tons):	
BMP:	
Total Repair Costs:	
Comments/Notes:	

PS2

Site PS3

County:	Muskegon
Waterbody:	Pillon-Staple
Road Crossing:	Pillon Rd. (North)
GPS:	N43°19.640 - W86°11.233
Priority Ranking:	**LOW**
Culvert Ranking	Bad
Site Length:	
Bank Height:	
Soil:	Sands, loamy sand
Recession Rate:	
Loss / Year (tons):	
BMP:	
Total Repair Costs:	
Comments/Notes:	

PS3

Site PS4

County:	Muskegon
Waterbody:	Pillon-Staple
Road Crossing:	Riley Thompson
GPS:	N43°20.315 - W86°11.636
Priority Ranking:	**HIGH**
Culvert Ranking	Bad
Site Length:	70
Bank Height:	4
Soil:	Sands, loamy sand
Recession Rate:	0.4
Loss / Year (tons):	6.16
BMP:	Streambank Stabilization Structure
Total Repair Costs:	$3,385
Comments/Notes:	*Stilling basin*

PS4

Site PS5

County:	Muskegon
Waterbody:	Pillon-Staple (south)
Road Crossing:	Railroad Crossing
GPS:	N43° – W86°
Priority Ranking:	**LOW**
Culvert Ranking	Good
Site Length:	15
Bank Height:	2
Soil:	Sands, loamy sand
Recession Rate:	0.03
Loss / Year (tons):	0.05
BMP:	Streambank Stabilization Structure
Total Repair Costs:	$2,665
Comments/Notes:	*Stilling basin*

PS5

Site PS6

County:	Muskegon
Waterbody:	Pillon-Staple
Road Crossing:	Staple Rd.
GPS:	N43°20.527 – W86°11.824
Priority Ranking:	**MEDIUM**
Culvert Ranking	Good
Site Length:	15
Bank Height:	3
Soil:	Sands, loamy sand
Recession Rate:	0.13
Loss / Year (tons):	0.32
BMP:	Streambank Stabilization Structure
Total Repair Costs:	$1,105
Comments/Notes:	*Ditch with rocked sides, streambank protections*

PS6

Site PS7

County:	Muskegon
Waterbody:	Pillon-Staple (north)
Road Crossing:	Railroad Crossing
GPS:	N43° – W86°
Priority Ranking:	**MEDIUM**
Culvert Ranking	Bad
Site Length:	30
Bank Height:	2
Soil:	Sands, loamy sand
Recession Rate:	0.13
Loss / Year (tons):	0.43
BMP:	Streambank Stabilization Structure
Total Repair Costs:	$2,365
Comments/Notes:	*Stilling basin*

PS7

Site PS8

County:	Muskegon
Waterbody:	Pillon-Staple
Road Crossing:	Staple Rd.
GPS:	N43°19.640 - W86°11.233
Priority Ranking:	**MEDIUM**
Culvert Ranking	Bad
Site Length:	200
Bank Height:	10
Soil:	Sands, loamy sand
Recession Rate:	0.13
Loss / Year (tons):	14.30
BMP:	Watercourse Crossing
Total Repair Costs:	$3,060
Comments/Notes:	*Fencing with land closure – Horse pasture*

PS8

Site FD1

County:	Muskegon
Waterbody:	Furman Drain
Road Crossing:	Beatie Rd.
GPS:	N43°19.136 – W86°10.641
Priority Ranking:	**LOW**
Culvert Ranking	Good
Site Length:	
Bank Height:	
Soil:	Sands, loamy sand
Recession Rate:	
Loss / Year (tons):	
BMP:	
Total Repair Costs:	
Comments/Notes:	

FD1

Site FD2

County:	Muskegon
Waterbody:	Furman Drain
Road Crossing:	M-120
GPS:	N43°19.355 – W86°10.055
Priority Ranking:	**LOW**
Culvert Ranking	Good
Site Length:	
Bank Height:	
Soil:	Sands, loamy sand
Recession Rate:	
Loss / Year (tons):	
bmp	
Total Repair Costs:	
Comments/Notes:	

FD2

Site FD3

County: Muskegon
Waterbody: Furman Drain
Road Crossing: Bard Road
GPS: N43°19.422 – W86°09.915
Priority Ranking: **LOW**
Culvert Ranking Good
Site Length:
Bank Height:
Soil: Sands, loamy sand
Recession Rate:
Loss / Year (tons):
BMP:
Total Repair Costs:
Comments/Notes:

FD3

Site FD4

County: Muskegon
Waterbody: Furman Drain
Road Crossing: Sweeter Road
GPS: N43°19.860 – W86°09.966
Priority Ranking: **LOW**
Culvert Ranking Bad
Site Length:
Bank Height:
Soil: Sands, loamy sand
Recession Rate:
Loss / Year (tons):
BMP:
Total Repair Costs:
Comments/Notes:

FD4

Site FD5

County: Muskegon
Waterbody: Furman Drain
Road Crossing: Riley Thompson
GPS: N43°20.294 – W86°09.800
Priority Ranking: **LOW**
Culvert Ranking Good
Site Length:
Bank Height:
Soil: Sands, loamy sand
Recession Rate:
Loss / Year (tons):
BMP:
Total Repair Costs:
Comments/Notes:

FD5

Site FD6

County:	Muskegon
Waterbody:	Furman Drain
Road Crossing:	M-120
GPS:	N43°20.347 – W86°10.057
Priority Ranking:	**LOW**
Culvert Ranking	Good
Site Length:	
Bank Height:	
Soil:	Sands, loamy sand
Recession Rate:	
Loss / Year (tons):	
BMP:	
Total Repair Costs:	
Comments/Notes:	

FD6

Site BD1

County:	Muskegon
Waterbody:	Branstrom Drain
Road Crossing:	Pillon Road
GPS:	N43°18.812 – W86°11.230
Priority Ranking:	**LOW**
Culvert Ranking	Good
Site Length:	
Bank Height:	
Soil:	Sands, loamy sand
Recession Rate:	
Loss / Year (tons):	
BMP:	
Total Repair Costs:	
Comments/Notes:	

BD1

Site BD2

County:	Muskegon
Waterbody:	Branstrom Drain
Road Crossing:	M-120
GPS:	N43°18.847 – W86°10.758
Priority Ranking:	**HIGH**
Culvert Ranking	Good
Site Length:	800
Bank Height:	3
Soil:	Sands, loamy sand
Recession Rate:	0.4
Loss / Year (tons):	52.80
BMP:	Grade Stabilization Structure
Total Repair Costs:	$14,580
Comments/Notes:	*4 rock checks with sediment basin, 2 below M-120 and 2 between M-120 and Beattie. Streambank erosion occurring upstream and downstream – not directly related to crossing (bridge present).*

BD2

Site BD3	*2 locations / projects at site*	
County:	Muskegon	
Waterbody:	Branstrom Drain	
Road Crossing:	Beattie Rd.	
GPS:	N43° – W86°	
Priority Ranking:	**HIGH**	
Culvert Ranking	Good	
Site Length:	45	**BD3**
Bank Height:	2.5 (average)	
Soil:	Sands, loamy sand	
Recession Rate:	0.13 – 0.4	
Loss / Year (tons):	2.19	
BMP:	Streambank Stabilization Structure	
Total Repair Costs:	$3,740	
Comments/Notes:	*Rock chute – around inlet and side banks*	

Site BD4		
County:	Muskegon	
Waterbody:	Branstrom Drain	
Road Crossing:	Rich Rd.	
GPS:	N43° – W86°	
Priority Ranking:	**MEDIUM**	
Culvert Ranking	Good	
Site Length:	10	**BD4**
Bank Height:	2	
Soil:	Sands, loamy sand	
Recession Rate:	0.13	
Loss / Year (tons):	0.14	
BMP:	Grade Stabilization Structure (2)	
Total Repair Costs:	$2,240	
Comments/Notes:	*vegetated chutes*	

Site BD5		
County:	Muskegon	
Waterbody:	Branstrom Drain	
Road Crossing:	Dalson Rd.	
GPS:	N43° – W86°	
Priority Ranking:	**LOW**	
Culvert Ranking	Good	**BD5**
Site Length:		
Bank Height:		
Soil:	Sands, loamy sand	
Recession Rate:	0.03	
Loss / Year (tons):		
BMP:		
Total Repair Costs:		
Comments/Notes:		

Site BD6

County: Muskegon
Waterbody: Branstrom Drain
Road Crossing: Bard Rd.
GPS: N43° – W86°
Priority Ranking: **LOW**
Culvert Ranking Good
Site Length:
Bank Height:
Soil: Sands, loamy sand
Recession Rate:
Loss / Year (tons):
BMP:
Total Repair Costs:
Comments/Notes:

BD6

Site RD1

County: Muskegon
Waterbody: Ribe Drain
Road Crossing: Beatie Rd.
GPS: N43° – W86°
Priority Ranking: **LOW**
Culvert Ranking Good
Site Length:
Bank Height:
Soil: Sands, loamy sand
Recession Rate:
Loss / Year (tons):
BMP:
Total Repair Costs:

Comments/Notes:

RD1

Site RD2

County: Muskegon
Waterbody: Ribe Drain
Road Crossing: Bard Rd.
GPS: N43° – W86°
Priority Ranking: **LOW**
Culvert Ranking Good
Site Length:
Bank Height:
Soil: Sands, loamy sand
Recession Rate:
Loss / Year (tons):
BMP:
Total Repair Costs:
Comments/Notes:

RD2

Site RD3

County:	Muskegon
Waterbody:	Ribe Drain
Road Crossing:	Riley Thompson / Beatie
GPS:	N43° – W86°
Priority Ranking:	**LOW**
Culvert Ranking	Good
Site Length:	
Bank Height:	
Soil:	Sands, loamy sand
Recession Rate:	
Loss / Year (tons):	
Total Repair Costs:	
Comments/Notes:	

RD3

Site RD4

County:	Muskegon
Waterbody:	Ribe Drain
Road Crossing:	Michillinda Rd.
GPS:	N43° – W86°
Priority Ranking:	**MEDIUM**
Culvert Ranking	Good
Site Length:	20
Bank Height:	4
Soil:	Sands, loamy sand
Recession Rate:	0.13
Loss / Year (tons):	0.57
BMP:	Streambank Stabilization Structure
Total Repair Costs:	$2,230
Comments/Notes:	*Stilling basin – at side banks*

RD4

Site RD5

County:	Muskegon
Waterbody:	Ribe Drain
Road Crossing:	Railroad Crossing
GPS:	N43° – W86°
Priority Ranking:	**MEDIUM**
Culvert Ranking	Good
Site Length:	70
Bank Height:	2
Soil:	Sands, loamy sand
Recession Rate:	0.13
Loss / Year (tons):	1.00
BMP:	Streambank Stabilization Structure
Total Repair Costs:	$3,130
Comments/Notes:	*Stilling basin – at side banks*

RD5

Site RD6

County:	Muskegon
Waterbody:	Ribe Drain
Road Crossing:	M-120
GPS:	N43° – W86°
Priority Ranking:	**LOW**
Culvert Ranking	Good
Site Length:	N/A (60 yds. excavation)
Bank Height:	
Soil:	Sands, loamy sand
Recession Rate:	
Loss / Year (tons):	
BMP:	Stormwater Infiltration / Filter
Total Repair Costs:	$2,702
Comments/Notes:	*Open inlet at "Cargo" gas station on south side of Twin Lake*

RD6

Site RD7

County:	Muskegon
Waterbody:	Ribe Drain
Road Crossing:	Lake Rd.
GPS:	N43° – W86°
Priority Ranking:	**NOT EVALUATED**
Culvert Ranking	
Site Length:	
Bank Height:	
Soil:	Sands, loamy sand
Recession Rate:	
Loss / Year (tons):	
BMP:	
Total Repair Costs:	
Comments/Notes:	*Pipe outlet from lake to Ribe (greater than 300 ft. of pipe with water level control structure at outlet.*

RD7